ACKNOWLEDGMENTS

The National Airspace System (NAS) Architecture Version 4.0 is the joint product of the national aviation community. It exists today because of a lengthy development process that involved the Federal Aviation Administration (FAA) and every major aviation interest group in the United States.

This architecture is the integrated long-range plan for the NAS, which draws on new technologies and a dedicated FAA workforce to meet the increasing demands on our national air transportation system. It also deals with the realities of ever-expanding aviation travel and commerce and the realities of fiscal constraints. The challenge to develop this plan has been answered—and answered well.

It is impossible to directly credit each person involved with creating the NAS architecture. However, specific organizations inside and outside the FAA were *key* players in its development. They include:

Department of Transportation (DOT), the parent organization of the FAA

FAA organizations—Research and Acquisition (ARA), Air Traffic Services (ATS), and Regulation and Certification (AVR)

External organizations—RTCA, Incorporated; the Research, Engineering, and Development Advisory Committee (REDAC); Department of Defense (DOD); SETA (System Engineering and Technical Assistance contractor (TRW, ARINC, CTA, NYMA, RMS, SAIC, JTA, PMA)); MITRE Corporation/ Center for Advanced Aviation System Development (CAASD); and CSSI.

Special acknowledgment goes to the RTCA Free Flight Steering Committee and its select committee for building consensus on the direction of NAS modernization.

EXECUTIVE SUMMARY

This architecture is an evolutionary plan for modernizing the National Airspace System (NAS) and moving toward Free Flight. It incorporates new technologies, procedures, and concepts intended to meet the needs of NAS users and service providers.

The publication of the *National Airspace System Architecture Version 4.0* marks a major milestone for the Federal Aviation Administration (FAA). The first published version of the NAS Architecture (Version 2.0, October 1996) focused on sustaining existing infrastructure while evolving toward a system that supports Free Flight. Version 2.0 generated over 2,200 comments and initiated discussion about the need for an Air Traffic Services (ATS) concept of operations for a modernized NAS, aviation community needs, stable funding requirements for the FAA, and the required pace of NAS modernization. These issues were debated, with assistance from RTCA and the Research, Engineering, and Development Advisory Committee (REDAC).

Published in December 1997, the draft *NAS Architecture*, commonly referred to as Version 3.0 (V3.0), incorporated feedback from the aviation community; the new ATS document, *A Concept of Operations for the National Airspace System in 2005;* and anticipated funding levels. The draft generated over 1,600 comments. In response, the Administrator formed the NAS Modernization Task Force to examine the remaining NAS modernization issues and risks.

This document, *National Airspace Architecture Version 4.0*, incorporates previous comments; input from the Administrator's Modernization Task Force; and more realistic funding profiles for research, engineering, and development (R,E&D), facilities and equipment (F&E), and operations (OPS). This architecture, which covers the period 1998 to 2015, is based on: (1) the *Government/Industry Concept of Operation*, developed jointly by RTCA and the FAA, (2) ATS's *A Concept of Operations for the National Airspace System in 2005*, and (3) a set of capabilities recommended by the RTCA Task Force 3 Report on Free Flight.

In accordance with the evolutionary development paradigm recommended by RTCA and industry, certain maturing technologies in the architecture are deployed on a limited basis and assessed by the FAA and users. Results of the assessment will be used to modify the technologies, if required, prior to national deployment.

NAS modernization is implemented in three phases.

Phase 1 (1998–2002). Current NAS systems and services are maintained while new systems such as the Standard Terminal Automation Replacement System (STARS), display system replacement (DSR), and Wide Area Augmentation System (WAAS) are introduced.

The NAS Modernization Task Force recommended that a Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) program be implemented to mitigate risk and provide highly desired capabilities at selected locations before the end of 2002. The NAS Architecture Version 4.0 incorporated the FFP1 CCLD program as an initiative to provide early user benefits. FFP1 CCLD will deploy key automation capabilities to a limited number of sites within the NAS for formal evaluation by aviation stakeholders and FAA operators. Each capability will be evaluated for operational suitability and affordability prior to full-scale development or deployment.

To mitigate risk in the communications, navigation, surveillance (CNS) area, many of the ground systems, airborne avionics, decision support tools, supporting procedures, and training needed to provide an integrated set of capabilities will be tested in an operational environment during the Safe Flight 21 and Alaska Capstone programs. The results of Safe Flight 21 will drive national deployment strategies and timing for key CNS technologies.

Phase 2 (2003–2007). This phase concentrates on deploying new CNS and automation technologies to support the concept of operations.

Phase 3 (2008–2015). The required infrastructure for modernizing the NAS will be completed. Automation advancements integrated with new CNS technologies will result in less restrictions and more Free Flight capabilities throughout the NAS.

Capabilities

The NAS will be modernized incrementally. New systems will replace older ones, and new capabilities derived from advanced technologies and/or procedures will be added. The new capabilities will be a result of integrating new systems, airspace changes, procedures, training, avionics, and rulemaking. This architecture identifies and synchronizes the activities necessary for fielding a capability to provide benefits as early as is affordable under current and projected funding.

The following paragraphs describe the evolution of the NAS provided in the architecture by functional and domain areas.

Navigation, Landing, and Lighting Systems. In Phases 1 and 2, the ground-based navigation infrastructure will transition to a satellite-based system that uses the Global Positioning System (GPS) augmented by WAAS and the Local Area Augmentation System (LAAS). This satellite-based navigation and landing architecture will provide the basis for NAS-wide direct routing and guidance signals for precision approaches to most runway ends in the NAS, and it will reduce the variety of navigation avionics required aboard aircraft. Some ground-based navigational systems may be retained to back up satellite-based navigation operations along principal air routes and at high-activity airports.

Surveillance. The NAS architecture calls for evolution from the current primary and secondary radar systems to digital radar and automatic dependent surveillance (ADS). This change is designed to improve and extend surveillance coverage and provide the necessary flexibility for Free Flight. After data from weather radars become available on the new en route controller displays (i.e., DSR), primary radar will be phased out of en route airspace.

A new radar for approach control services (the ASR-11) will include weather-detection capability. The weather capability of the ASR-9 radar will be improved with the addition of the weather system processor (WSP). Primary radars will also be installed at more airports for airport surface surveillance. Secondary surveillance radars (SSR) with selective interrogation (SI) capability will be used in both en route and terminal airspace.

Based on successful Safe Flight 21 demonstrations and better definition of user benefits, users are expected to equip with automatic dependent surveillance broadcast (ADS-B) for air-air surveillance during Phase 1. If users do so, ADS, based on ADS-B, will be implemented during Phase 2 to enhance en route, terminal, and airport surface surveillance. ADS, based on automatic dependent surveillance addressable (ADS-A), is planned to provide surveillance in oceanic airspace in Phase 2.

Communications. The FAA will transition from analog voice and commercial service-provider data link communications to an integrated digital communications capability. Data link communications in Phase 1 will evolve as new applications are tested. Implementation of data link will reduce voice-channel congestion and increase the capacity of each very high frequency (VHF) frequency. During Phase 2, the FAA will begin replacing its analog air-ground radio infrastructure with digital radios (next-generation air-ground communication system (NEXCOM)). The capability of NEXCOM radios to provide digital voice and data communications will be implemented gradually during Phases 2 and 3. Ground-ground operational and administrative communications systems will be combined into an integrated, ground digital telecommunications system.

Avionics. Aircraft are expected to gradually transition to avionics that use satellite technology (GPS WAAS/LAAS) for navigation, landing, and reporting position information to other aircraft (ADS-B) and surveillance systems. The GPS WAAS/LAAS receivers will enable pilots to navigate via direct routes and to fly precision instrument approaches to virtually any runway. Aircraft radios will also be replaced for compatibility with the new, digital air-ground communications infrastructure. New, multifunctional cockpit displays will show the position of nearby ADS-B-equipped aircraft, provide moving map displays, and present data-linked information, such as graphical weather and notices to airmen (NOTAMs). Lengthy transition periods are designed into the architecture to accommodate the varying avionics transition schedules of all NAS users (i.e., airlines, general aviation (GA), and the Department of Defense (DOD)).

Information Services for Collaboration and Information Sharing. Integrated NAS information services will be the basis for operational planning improvements such as receiving and sharing common data and the ability to make joint planning decisions. A systemwide computer network with standardized data formats will allow NAS information services interoperability. The NAS-wide information services will evolve from today's current array of independent systems and varying standards to a shared environment that connects users and service providers for traffic flow management, flight service, and aviation weather information.

Traffic Flow Management. Air traffic management (ATM) encompasses traffic flow management (TFM) and air traffic control (ATC) capabilities and is designed to minimize air traffic delays and congestion while maximizing overall NAS throughput, flexibility, and predictability. TFM is the strategic planning and management of air traffic demand to ensure smooth and efficient traffic flow through FAA-controlled airspace.

TFM capabilities are managed primarily at the Air Traffic Control System Command Center (ATCSCC). Some functionality is distributed to traffic management units at air route traffic control centers (ARTCCs), high-activity terminal radar approach control (TRACON) facilities, and at the highest-activity airport traffic control towers (ATCTs). The Enhanced Traffic Management System (ETMS) will be updated with new tools. For example, the new control-by-time-of-arrival (CTA) tool will give users the capability to determine which flights and departure times are suitable for the capacity at the destination airport. The FAA will provide ground delay program (GDP) data to airline operations centers (AOCs). GDP data include operative airport acceptance rates, which will enable airlines to respond with revised, suitable flight schedules. A further enhancement, interactive flight plan filing, will enable FAA automation systems to provide feedback on system constraints and options to users' flight plans.

En Route. The current ARTCC computer hardware and software infrastructure will be replaced with new hardware, software, and operating systems. During Phase 1, new controller workstations (i.e., DSRs) will be installed and the current Host computer hardware will be replaced with a new computer (the Host/oceanic computer system replacement (HOCSR)) that uses the existing software applications. Controller tools such as conflict probe and the Center TRACON Automation System/Traffic Management Advisor (CTAS/TMA) will be implemented on outboard processors as part of the FFP1CCLD program. During Phase 2, the existing software applications will be recoded and new applications added to support air traffic control functions. During Phase 3, this modern computer infrastructure is expected to support advanced traffic management capabilities that support the movement toward Free Flight.

Oceanic and Offshore. During Phase 1, manual aircraft tracking that currently relies upon verbal pilot position reports will transition to satellite-based position reports received via data link. Communications between oceanic controllers and pilots will also be through satellite data link. During Phase 2, the oceanic infrastructure will be upgraded to use automatic data-linked position reports for automated aircraft tracking. In Phase 3, as the oceanic communications, surveillance, and automation capabilities for air traffic management improve, separation between properly equipped aircraft will continue to be reduced.

Terminal. A combination of ground automation and airborne systems will allow flexible departure and arrival routes and reduce or eliminate speed and altitude restrictions. During Phases 1 and 2, the existing terminal automation system will be replaced with the STARS. During Phase 2, the terminal automation infrastructure will evolve to incorporate new air traffic control functions such as ADS and weather information from the Integrated Terminal Weather System (ITWS). During Phase 3, the hardware and software will be improved to accommodate advanced controller tools such as conformance monitoring, conflict detection, and enhanced arrival/departure sequencing. These tools will enable controllers to maintain clear weather aircraft-acceptance rates at airports during inclement weather conditions.

Tower/Airport Surface. The tower/airport environment will evolve from having minimal automation support to having expanded use of data link, improved surface surveillance displays, and decision support tools. During Phase 1, the initial surface movement advisor (SMA), as part of the FFP1 CCLD initiative, will provide airline ramp control operators with arrival and departure information. New automation systems and increased information exchange among airport operators and users (i.e., airline operations centers, aircraft, and surface vehicles) will be implemented during Phases 2 and 3 to provide dynamic surface movement planning. This dynamic planning enables users and service providers to balance arrivals, departures, runway demand, gate changes, taxi routes, and deicing requirements.

Flight Services. Flight planning information distribution will evolve to provide easier access to information on weather, special use airspace (SUA) status, traffic management initiatives, and NOTAMs. During Phase 1, the current flight service automation systems will be replaced by the new Operational and Supportability Implementation System (OASIS). During Phases 2 and 3, OASIS will be integrated with the NAS-wide information network for improved information sharing.

Aviation Weather. The current NAS standalone weather systems will evolve and become integrated into a weather server so that information is single-source and shared by all systems. Weather information gathered and processed at the servers will be available to users and service providers in a more timely manner, promoting common situtational awareness and enhancing collaborative decisionmaking for controllers, traffic managers, aircrews, and dispatchers. In Phase 1, two key systems will be implemented, ITWS for terminal airspace and the weather and radar processor (WARP) for en route airspace.

Infrastructure Management. The current decentralized method of managing equipment maintenance will be replaced by a centralized method that will expand the FAA's reliance on remote monitoring and restoral of systems. New air traffic control equipment will include remote monitoring and restoral features to support this management strategy. This will enable the FAA to manage the infrastructure nationally rather than regionally and allow users to collaborate on service restoration priorities.

Conclusion

This architecture is a plan for an evolutionary approach to NAS modernization in which current NAS capabilities are sustained or improved while new technologies are introduced. In this architecture, the FAA and the NAS users have identified which technologies are likely to provide significant benefits, how to evaluate them, and when to implement them (contingent on affordability).

The risks associated with some of the new technologies will be mitigated by FFP1 CCLD and the Safe Flight 21 and Alaska Capstone programs, which provide for operational testing in a limited area prior to national deployment. Technology growth, funding levels, and other factors can and probably will affect the course of modernization. As new information arises, the FAA and the NAS users will collectively revise the architecture to refine the course of NAS modernization.

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PART I

INTRODUCTION TO THE NAS ARCHITECTURE

1 PART I INTRODUCTION TO THE NAS ARCHITECTURE OVERVIEW

The National Airspace System (NAS) architecture is an evolutionary plan for modernizing the NAS and moving toward Free Flight. It incorporates new technologies, procedures, and concepts to meet the needs of NAS users and service providers.

The NAS architecture is a result of intense Federal Aviation Administration (FAA) and aviation industry involvement in capturing and restructuring the requirements for a modernized, safer, and more efficient NAS. The NAS architecture describes the system support, operational concepts, schedules, human and physical resources, and other actions essential for maintaining NAS safety, capacity, and performance.

The modernized NAS will offer greater flexibility and functionality through systems that are based on up-to-date technology, information sharing, and common data exchange evolving over time. However, during this evolution, the NAS must be sustained to operate without interruptions.

This architecture is derived from internal and external briefings and reviews by the FAA and industry groups, as well as from thousands of comments on previous releases. The architecture attempts to respond to all comments and concerns, while considering the realities of the anticipated FAA budget constraints over the next 20 years.

Document Organization

The narrative is organized to give readers a comprehensive understanding of the entire architecture and to direct them to a specific portion of the document for more detailed information. References to source information are provided for a more in-depth understanding.

The *Government/Industry Concept of Operations*, Air Traffic Services’ Concept of Operations, and the concepts expressed in the Free Flight Action Plan all have had a major impact on the architecture and are referenced throughout the document.

This document is organized into five parts, as shown in Figure 1-1, Roadmap of the NAS Architecture Document. Part I, Introduction to the NAS Architecture, provides an overview and discussion of previous documents and how this document has evolved. It also describes the modernized NAS and how the various users benefit from it.

Part II, NAS Architecture Supporting Elements, covers the evolution of NAS capabilities and the costs of modernization. Additionally, it summarizes the architecture in the following areas critical to successful NAS modernization: Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD), Safe Flight 21, and Capstone program descriptions; risk mitigation; safety; human factors; security; research, engineering, and development; regulation and certification; and personnel.

Details of functional area changes are described in Part III, NAS Architecture Description, which introduces the core of the logical architecture. Each section addresses how that portion of the NAS is evolving. The functional area sections appear in the following format:

- Overview
- Evolution
- Summary of Capabilities
- Human Factors
- Transition
- Costs
- Watch Items.

A summary is presented in Part IV. Part V, Appendixes, contains the list of acronyms, participating organizations, references, and the NAS capabilities diagrams and matrix.

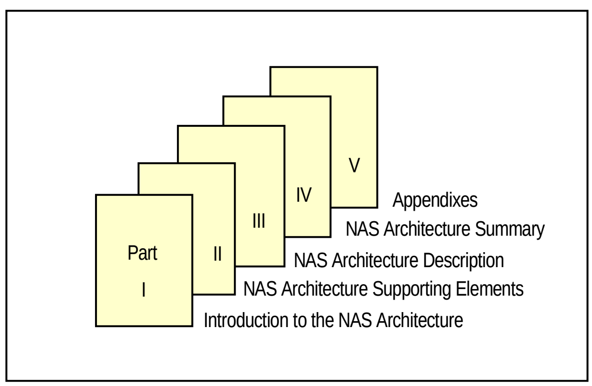


Figure 1-1. Roadmap of the NAS Architecture Document

The FAA understands the business needs and concerns of NAS users and has attempted to address these concerns in the NAS architecture. The architecture is both a planning tool and a "living" document. As needs, technology, and operating concepts change, the architecture will be up-dated to accommodate the impact of those evolving changes.

2 INTRODUCTION

The release of the *NAS Architecture Version 4.0* marks a major planning milestone in the NAS modernization process. For the past 2½ years, the FAA has worked closely with the user community to develop a better understanding of its requirements for a safer and more efficient NAS.

2.1 Developing the Architecture

This architecture has evolved from earlier work. *NAS Architecture Version 2.0's* release in October 1996 resulted in the submission of over 2,200 comments. After the December 1997 draft *NAS Architecture* (Version 3.0) was distributed, over 1,600 comments were received. All of the comments were considered in developing this architecture. The architecture has been coordinated within the FAA and with the aviation community. Appendix B lists the organizations that participated in the architecture's development. An overview of Architecture Version 4.0, the *Blueprint for NAS Modernization,* was also published in January 1999.

This architecture has been designed to achieve the following principles:

- Enhance overall NAS safety
- Introduce user benefits early and adapt to user needs
- Maintain and enhance existing services
- Modernize in an evolutionary manner using new technologies
- Use standard components, common systems, and common user interfaces wherever possible
- Ensure adequate security of systems and information
- Ensure compatibility across systems by using accepted systems engineering methodologies
- Give users and service providers wide access to NAS information
- Design the system to be adaptable and easily extensible as requirements change and traffic grows
- Make the architecture executable by staying within the FAA's funding projections.

The aviation community wants improved safety and capacity, increased flexibility, more access to airspace, and a larger role in decisionmaking.

Key internal and external events shaped the architecture.

Responsiveness to Customers. The FAA intends to be more responsive to its customers—the NAS users. Users clearly expressed their desire for a NAS that is more efficient and provides more benefits. These views were stated in the RTCA Task Force 3 Free Flight report.[1] The aviation community painted a picture of a NAS that meets its needs for more flexible routes and a larger role in the decisionmaking process that directs NAS operations.

A draft architecture, dated August 7, was provided to the RTCA Free Flight Steering Committee for review and comments. In its response, the steering committee recommended that the FAA release the NAS Architecture Version 4.0 as a baseline for managing NAS modernization. The RTCA response (see comments at the end of this section) provided six general themes and a list of more detailed comments on selected sections of the architecture. Some of the themes are beyond the scope of this document, while other themes require further discussion and consideration within the aviation community. Most of the detailed comments have been addressed in this document; the remaining comments require additional discussion and analysis before they can be incorporated. This work is underway as the FAA addresses the detailed transition steps in NAS modernization.

Modernization Plan. The White House issued Executive Order 13015, which established the White House Commission on Aviation Safety and Security after the loss of Trans World Airlines

1. *RTCA Task Force 3: Free Flight Implementation,* October 1995.

Flight 800. Key recommendations of the commission were: (1) that the FAA should develop a revised NAS modernization plan and set a goal of the modernized system being fully operational nationwide by the year 2005, and (2) that the Congress, the Administration, and users should develop innovative means of financing this acceleration. [2]

Safety. NAS Modernization will enhance safety through more effective risk management in critical areas of the aviation system. Recently, the FAA's focused safety agenda, "Safer Skies," identified high-priority safety concerns. Additionally, the FAA Administrator has established a risk management policy and has implemented safety risk management as a decisionmaking tool within the FAA. Modernization will strengthen safety risk management in several of these high-priority areas by reducing the potential for controlled flight into terrain and runway incursions, improving flow control of approach and landing operations, and providing better weather information.

Security. Another area of great importance to the FAA and the nation is protection of NAS aviation information systems against electronic intrusion and disruption. Information security has become an increasingly important component of the architecture and the modernization effort. A key recommendation of the White House Commission on Aviation Safety and Security was: "The FAA should establish a security system that will provide a high level of protection for all aviation information systems." Eight months later, the President's Commission on Critical Infrastructure Protection restated this recommendation as: "The Commission recommends the FAA act immediately to develop, establish, fund, and implement a comprehensive National Airspace System Security Program to protect the modernized NAS from information-based and other disruptions, intrusions, and attack."

Reform. The FAA recognized that it would need personnel and acquisition reforms in order to implement modernization. Less restrictive personnel policies allow the right talents to be applied to tasks in a more timely fashion. Streamlined acquisition procedures[3] allow new technologies to be acquired and fielded in less time and at lower cost.

Funding. The question of adequate funding levels for modernization was publicly examined. As directed by the Federal Aviation Reauthorization Act of 1996, Public Law 104-264, the FAA Administrator selected Coopers and Lybrand, L.L.P., to conduct an independent analysis of the FAA's budgetary requirements through fiscal year 2002. These results were provided to the National Civil Aviation Review Commission, which was tasked to evaluate the state of the NAS, determine the need and cost of modernization, and provide recommendations on funding sources. The commission's report clearly states that modernizing the aging NAS infrastructure is critically important and that a sufficient, stable funding source for modernization and the FAA must be identified.

Concepts of Operations. Two concepts of operations were a result of discussions between users of NAS services and FAA service providers. The FAA Air Traffic Services (ATS) organization's *A Concept of Operations for the National Airspace System in 2005* was distributed, followed by the *Government/Industry Concept of Operation,* developed jointly by RTCA and the FAA. Together, the concepts of operations define the capabilities and services needed in a modernized NAS and provide the general time frame for each capability. In this architecture document, the two concepts of operations (i.e., ATS's and the government/industry's) are *jointly* referred to as the CONOPS. This is possible because one is from a service provider perspective, the other reflects the user's perspective.

The labor agreement with the National Air Traffic Controllers Association (NATCA) in late 1998 reclassified air traffic control facilities. The effects of this reclassification on the total number of controllers required, and their salaries, have not been considered in the NAS Architecture Version 4.0.

Modernization Task Force. After distributing the draft *National Airspace Architecture 1997* (Version 3.0) in December 1997, the Administrator formed the NAS Modernization Task Force.

2. *White House Commission on Aviation Safety and Security, Final Report,* February 12, 1997, p. 20.
3. Federal Aviation Administration Acquisition Management System, June 1997.

The Task Force was charged with closing the gaps between the FAA and the aviation community's positions on the risks of NAS modernization. After consulting with industry (through RTCA), the Task Force concluded that users want the benefits of certain key technologies sooner than originally planned for in the NAS Architecture Version 3.0. The Task Force also recommended that users play a larger role in evaluating the potential benefits of modernization. This resulted in the formation of the Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) program, which is discussed in Section 6.

The NAS architecture balances the capabilities requested by users and service providers, the funding level and sources that are expected to be available for modernization, the cost to users and their ability to equip, and the FAA's ability to manage the changes needed to make modernization a reality. Although other architectures are possible, Version 4.0 represents a plan based on a balance between needs and available resources.

2.2 Overview of the NAS

Today's System. Today's NAS is based on traffic patterns of the past, operations of a regulated industry, and information that is isolated by the limitations of obsolete computers. Additionally, accommodating the growth in air traffic is constrained by navigation and air-ground communications spectrum congestion.

Above all, the entire NAS is aging rapidly. Other countries, especially those without a major investment in an existing infrastructure, have already begun using modern technology for their aviation systems. This architecture will be in harmony with the global community. It is the goal of this architecture and the continuing architectural process to provide the roadmap for making our aviation system the safest, most cost-effective, and efficient system possible for the resources available.

The NAS is a complex collection of systems, procedures, facilities, aircraft, and people. The NAS includes thousands of pieces of equipment in hundreds of locations throughout the United States. These components comprise one system that ensures safe and efficient operations (see Figure 2-1). Thousands of people operate the equipment used to provide NAS services to the aviators and passengers who travel each day. The 18,000 plus airports in the United States are also a significant part of the NAS, particularly the more than 3,300 airports that are the core of the national transportation system and receive grants under the Airport Improvement Program. Airports of national importance include all commercial service airports, all reliever airports, and selected general aviation airports.

The main NAS users are air carriers, air cargo, commuter air carriers, air taxis, general aviation, the military, and civilian government. Air carriers conduct scheduled and nonscheduled operations using aircraft weighing more than 7,500 pounds and with 9 or more seats. Commuter air carriers conduct scheduled operations using aircraft weighing less than 7,500 pounds and with less than 9 seats. Air taxi operators are air carriers who conduct on-demand instead of scheduled operations. Air cargo flights carry freight and packages but not passengers. General aviation (GA) includes private pilots, business aviation, and all civilian operations not included above. A wide spectrum of government operations includes military aircraft, the Coast Guard, the Department of Justice, and other government agencies.

Each user group has special needs that must be balanced within the architecture. Commercial operations account for about 95 percent of aviation's impact on the economy.[4] There are over 260,000 GA pilots. The Department of Defense (DOD) has the world's largest fleet, with more than 16,000 aircraft.

As a plane departs the airport, tower, terminal, and en route controllers ensure that it does not conflict with other traffic during its climb to cruising altitude. The en route controllers ensure separation is maintained while en route to the destination airspace where the aircraft is once again controlled by terminal and tower controllers for arrival and landing. Figure 2-2 graphically depicts the various NAS domains.

Navigation systems provide position information to aircraft during flights and for landings. The

4. *The Economic Impact of Civil Aviation on the U.S. Economy, Update '93*, Wilbur Smith Associates, April 1995.

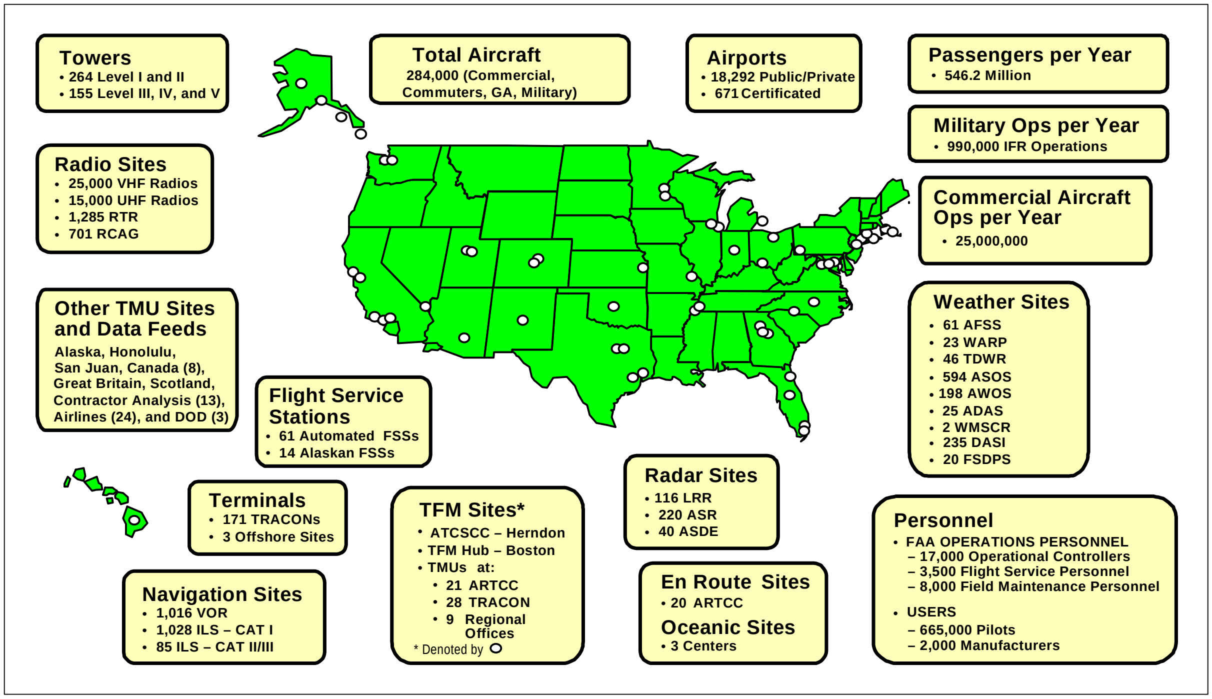


Figure 2-1. The NAS

The NAS is a complex collection of systems, procedures, facilities, aircraft, and people. These components work together as one system to ensure safe and efficient operations.

FAA uses radars to provide surveillance data (i.e., aircraft position) to controllers.

Automation systems assist controllers at oceanic, en route, terminal, and tower locations. Radios allow pilots and controllers to communicate, enabling safe and efficient operations.

Flight service stations (FSSs) assist GA pilots to plan and file flight plans. Airline operations centers (AOCs) work closely with traffic flow managers to plan commercial flights. Planning functions help pilots account for weather and winds along their intended routes and also help the FAA ensure that the demand is balanced for safe operations.

2.3 Modernizing the NAS

Key goals of modernizing the NAS are to provide existing services more efficiently and to provide new services and capabilities that will move the NAS toward a new type of operating environment known as Free Flight.

These goals must be achieved under two constraints: safety will not be compromised, and annual costs to the FAA and users must be kept at a reasonable level.

Service providers and service users interact with each other at three levels: a strategic level (e.g., an airline decision to establish an east coast hub); an operational level (e.g., an airline decision on which city to select for that hub—along with the routes, equipment, and frequency and time of service); and a tactical level (e.g., day-to-day decisions—both on the ground and in the air—on the operation of the hub regarding weather, equipment outages, and known traffic delays).

Given the complexity of the system, the FAA seeks to maintain a flexibility that allows users to achieve individual objectives. The objectives of an airline's operations may be much different from those of GA or DOD operations.

This complexity also is why modernization requires the active participation of all parts of the FAA and user communities. Modernizing even a single NAS function, such as navigation, affects FAA organizations and a broad range of users.

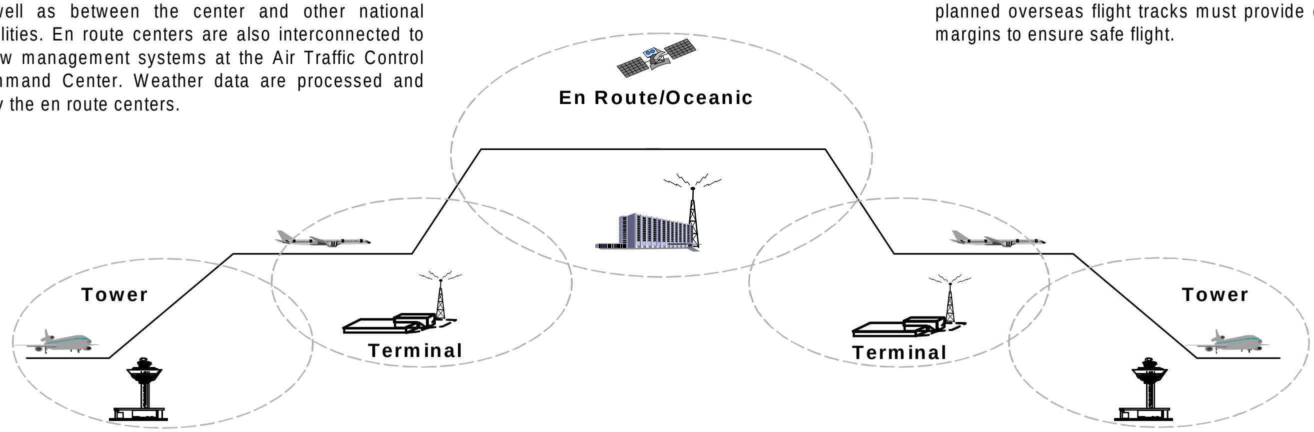
Figure 2-3 illustrates the complexity of the process and the interactions and activities needed to achieve modernization.

En Route

Twenty en route centers control domestic air traffic not specifically delegated to an oceanic, terminal, or tower control facility. The airspace extends out to 100 miles beyond the United States coastlines and its borders with Canada and Mexico. The en route centers operate the computer suite that processes radar surveillance and flight planning data, reformats it for presentation purposes, and sends it to the displays used by controllers to track aircraft. En route centers control the switching of voice communications between aircraft and the center as well as between the center and other national airspace facilities. En route centers are also interconnected to the traffic flow management systems at the Air Traffic Control System Command Center. Weather data are processed and distributed by the en route centers.

Oceanic

The oceanic air traffic control centers control aircraft over portions of the Atlantic, Arctic, and Pacific oceans. Two oceanic centers are co-located with en route centers in New York and Oakland, while a third is located at Anchorage, Alaska. The air traffic control provided over the ocean is substantially different from that provided over land, because there are no surveillance systems that can provide exact aircraft position. Position reports based on on-board aircraft navigational systems are radioed to the controller. Due to the uncertainty in position report reliability, planned overseas flight tracks must provide greater separation margins to ensure safe flight.



Tower

Tower controllers manage and control the airspace within approximately five miles of an airport, including taxiways and runways on the ground. Tower controllers control ground operations on airport taxiways and runways and departing and landing traffic. Towers are provided with flight planning information by the en route computer suite. Weather information is available from the weather processing and distribution communications network.

Terminal

Terminal facilities provide air traffic control services for an air space located approximately 5 to 40 miles from an airport and usually below 10,000 feet in altitude. The terminal controller establishes and maintains the sequence and separation of aircraft taking off, landing, or operating within the terminal airspace. Terminals are interconnected with local towers and provide surveillance and position data of aircraft under terminal control to specialized displays within the tower. Selected terminal facilities are interconnected to the traffic flow management systems at the Air Traffic Control System Command Center. Flight planning information is provided from the en route computer suite. Weather data are provided from the weather processing and distribution communications network.

Figure 2-2. NAS Functional Domains

2.4 Free Flight

The main objective of NAS modernization is moving the NAS towards a new type of operating environment known as Free Flight.

The RTCA defines Free Flight as:

“. . . a safe and efficient operating capability under instrument flight rules in which the operators have the freedom to select their path and speed in real time. Air traffic restrictions are imposed only to ensure separation, to preclude exceeding airport capability, to prevent unauthorized flights through special use airspace, and to ensure safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity which removes restrictions represents a move toward Free Flight.”[5]

Users will derive benefits from the removal of current air traffic control (ATC) constraints and restrictions to flight operations. The benefits will be reflected in an operational environment that provides more efficient management of airspace and airport resources through better information exchange and collaborative decisionmaking among users and service providers.

Under the current system, users file flight plans along FAA-defined air routes determined by a system of ground-based navigational aids (Navaids); however, significant “free flight” area navigation (i.e., more direct routing) takes place above Flight Level 290 through the National Route Program.

The lack of flexibility of the current NAS is due to the inherent constraints of the older technologies used for communications, navigation, surveillance, computer systems, and decision support aids. The future NAS will include new technologies that support capabilities that will allow users and providers more flexibility in planning and in flight operations.

A key benefit to users will be their ability to select and use efficient flight profiles, a key aspect of Free Flight. The combination of cockpit technol-

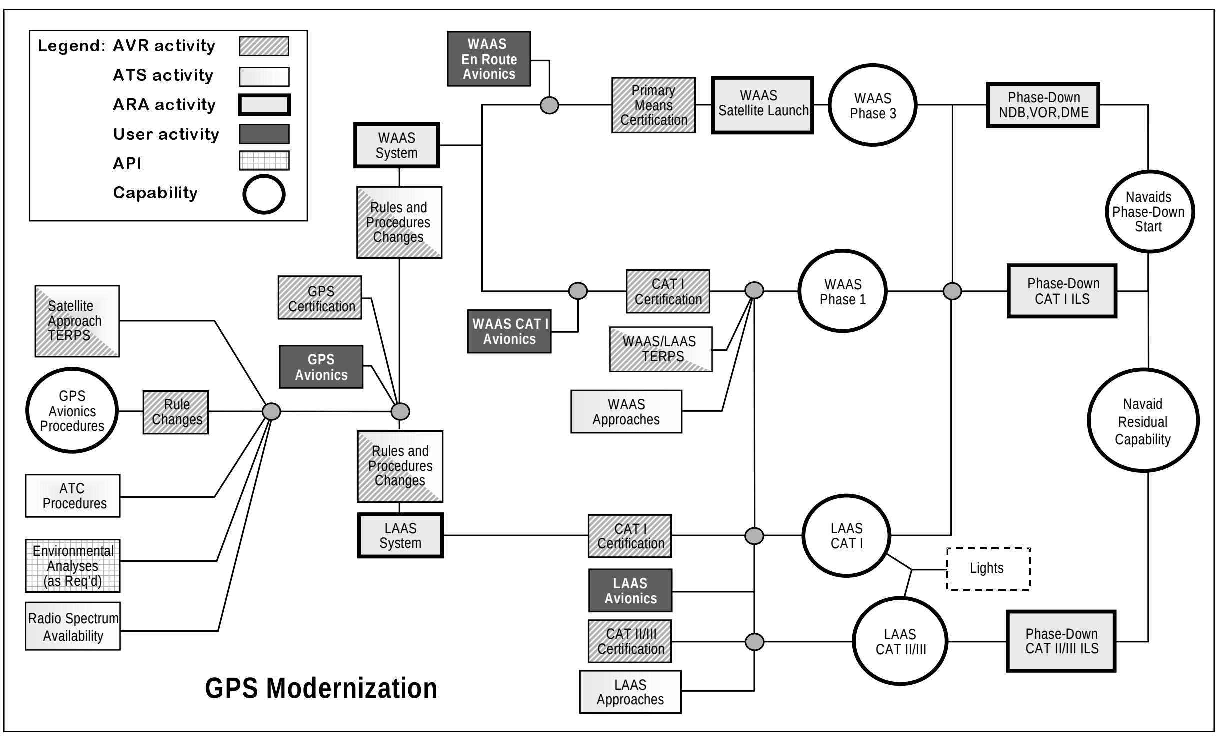


Figure 2-3. Modernization is an Aviation-Community-Wide Task

Deploying new systems, although a significant and critical step, is not sufficient to enable new capabilities and services. New procedures, new avionics, new rules, and public hearings are all integral to NAS modernization. The FAA and user community must work together to realize the benefits of a modernized NAS.

5. Free Flight Action Plan Update, April 2, 1998, pp. 2-3.

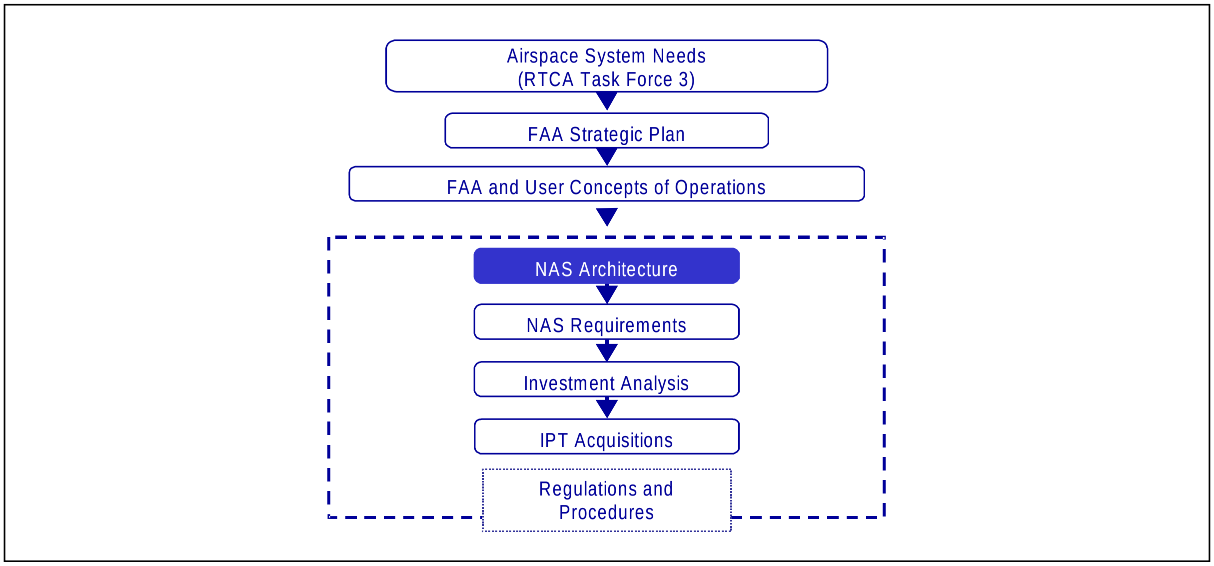


Figure 2-4. The NAS Architecture in Context

A logical architecture, based on the FAA and the Government and Industry Concepts of Operations, the architecture defines the path for NAS modernization. The architecture's approach to modernization strikes a balance between the desires of NAS users, available funding, safety, and the speed at which transitions can occur.

ogy and satellite-based navigation will enable users to fly optimized climb profiles, and the most efficient cruise speeds, altitudes, and routes. Flight planners and pilots will be able to select the most fuel-efficient routes based upon winds aloft and fly optimal descent profiles to the destination airport.

2.5 Role of the Architecture in NAS Modernization

The NAS architecture is the aviation community's roadmap for modernization. It describes the schedules and costs necessary to implement the capabilities and services defined in the CONOPS.

Figure 2-4 depicts the relationship between the Architecture and more strategic documents. Section 11, Regulation and Certification Activities Affected by New NAS Architecture Capabilities, discusses the architecture's regulatory impact.

The NAS Architecture Version 4.0 is a logical architecture. It provides a high-level description of NAS capabilities and services, the functions to be performed, their dependencies and interactions, and the information flow to support these functions. This architecture contains:

- The timing of functional enhancements and operational capabilities
- A sequence of infrastructure improvements
- FAA costs projected for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) budgets, including:
  – System acquisitions
  – Personnel
  – Infrastructure sustainment
- User cost estimates and schedules for equipage (air carrier, regional/commuter, GA, and military).

2.5.1 Using the Architecture Within the Aviation Community

The NAS architecture represents the FAA's commitment to the aviation community. It spells out in detail the vision that the FAA has for the modernized NAS, based on expected funding. It specifies the steps along the modernization path and the time frames for each. It shows FAA products, such as new systems or new capabilities provided by a combination of systems. The architecture also serves as a planning tool for the users of the NAS.

The FAA is working diligently to further understand the users' current aviation service needs.

Major capital purchases, such as avionics, require long lead times.

The architecture is a mechanism for continuing dialog on NAS modernization between the FAA and users.

The transition schedules in Version 4.0 assume a dual operations period of 5 years or more for avionics equipage. As navigational services are transitioned to satellite-based service, the FAA will coordinate with users before finalizing the schedules for phasing down Navaids or discontinuing ground-based services.

The architecture provides direction and challenges for research and development from now through 2015. The architecture is a plan for investigating benefits, examining alternatives, and developing applied technologies and procedures to meet the needs of aviation.

Finally, the architecture serves as a mechanism for a continuing dialog between the FAA and NAS users and becomes the point of departure for further refinement of NAS modernization requirements. The success of the process depends on user involvement.

2.5.2 Using the Architecture Within the FAA

Establishing long-range goals is a key element of the FAA's strategic planning process. The architecture provides a basis for the agency's mission analysis and program planning and defines specific strategic objectives to be achieved by 2015.

After extensive coordination within the FAA and the user community, the Joint Resources Council (JRC)[6] approved the NAS architecture and designated it as "baseline planning guidance" for the agency.

As illustrated in Figure 2-5, the architecture plays an important role in the FAA's new acquisition management system (AMS). The architecture describes the resources needed to modernize the NAS and meet user and service provider requirements. It identifies the required timing and numerous links that tie various programs together. Associated costs have also been estimated.

Funding requirements in the mid term and beyond will be used as starting points for future investment analyses. The JRC can use the architecture as a point of departure for mission need and in-

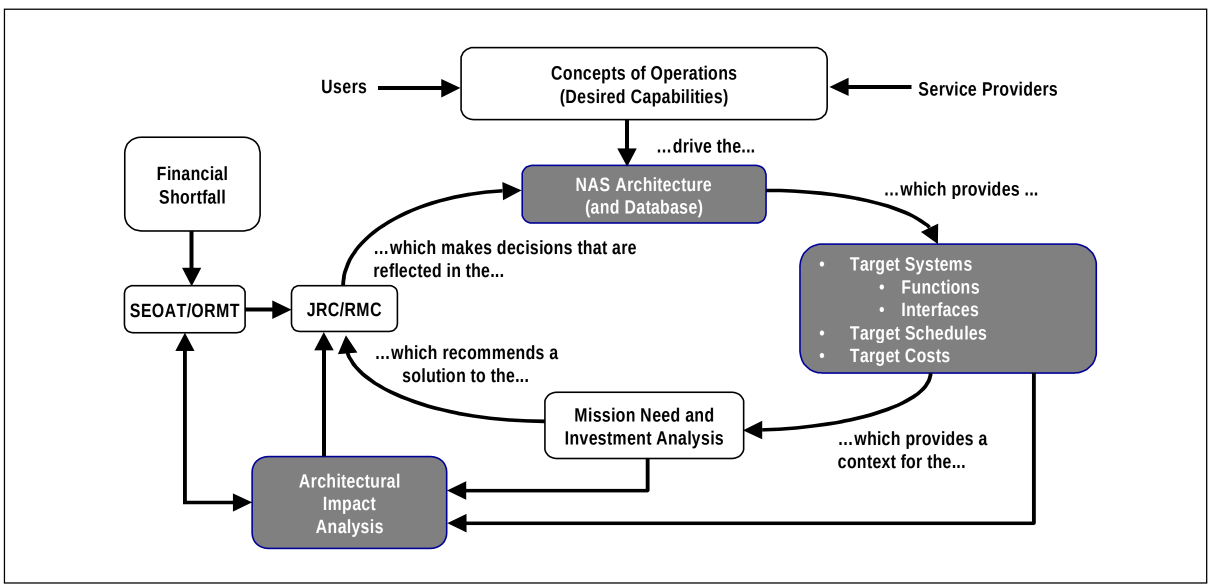


Figure 2-5. The NAS Architecture and the Acquisition Management System

The architecture provides the context for all FAA decisions. It enables decisionmakers to establish priorities and to understand how individual decisions affect the NAS.

6. The JRC is the FAA's top investment decision group.

vestment decisions. Plans made by the JRC or the Administrator and decisions affecting investments will be incorporated into the architecture, and changes will be made as required. User input to the architecture process will continue.

The architecture provides the context for investment analysis, with cost, schedule, and functional targets as starting points. It highlights the interdependencies of functions and capabilities. Although the architecture provides one candidate technical alternative to be analyzed, the investment analysis process may consider and select other alternatives. It provides a framework to use in assessing the implications of various alternatives and the implications of changes in funding, schedule, or functional targets.

This architecture is not an end state. Rather, it will continue to evolve based on the results of projects like Safe Flight 21, the availability of new technologies, new user and service provider requirements and priorities, and funding. Work continues to identify the new capabilities, systems, and activities required to modernize the NAS and achieve Free Flight. Funding requirements continue to be developed and validated. Production and installation schedules continue to be integrated to ensure that the various elements—including regulation and certification activities, new systems, user equipage, and procedural changes—are brought together at the correct time to provide benefits to users.

2.6 Near-Term Risk-Mitigation Activities

Modernizing the NAS will involve technology and cost risks. Some of the new technologies that may be used during modernization have not been tested or proven in an operational environment. Of equal significance are the new procedures that the Free Flight operational concept envisions. Important new controller decision support tools and aircraft air-air separation are two examples of new capabilities that require testing and validation prior to implementation. Three key risk-mitigation strategies the architecture will use are Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD), Safe Flight 21, and Capstone.

2.6.1 Free Flight Phase 1 Core Capabilities Limited Deployment

FFP1 CCLD incorporates guidance provided by the NAS Modernization Task Force. FFP1 CCLD is intended to provide early user benefits and mitigate technical risk by implementing key automation capabilities at specific sites within the NAS, for evaluation by aviation stakeholders and FAA operators. The deployments will allow computer-human interface (CHI), training, and safety factors to be evaluated. After the FAA and users have gained experience and evaluated the individual FFP1 CCLD capabilities, decisions will be made on whether to deploy them to additional locations.

2.6.2 Safe Flight 21

Many of the new technologies identified for modernization have been demonstrated in the laboratory or on a limited scale, but their true benefits and costs have not been conclusively established. These demonstrations, while instructive, have not been compelling enough to convince most NAS users to equip with modern avionics. Safe Flight 21 provides the opportunity to take these activities to the next logical step—full operational demonstration and validation, where significantly more accurate user and service provider cost-benefit assessments can occur.

Safe Flight 21 deploys and evaluates certain air traffic control systems and avionics, which use new communications, navigation, and surveillance technologies for determining technical risk and operational suitability. These new technologies include applications such as automatic dependent surveillance broadcast (ADS-B) for air-air and air-ground surveillance and flight information services via data link. Avionics, certification, and procedural development are cost and schedule risks that must be mitigated. Additionally, user benefits must be conclusively proven before avionics and associated ground equipment capital investments can be made.

2.6.3 Capstone

The FAA Alaskan Region's Capstone Program of infrastructure modernization will provide and validate safety and efficiency improvements recommended in the NTSB Safety Study *Aviation Safety in Alaska*. Capstone focuses on safety by improving infrastructure in Bethel and the surrounding area, a small portion of western Alaska. It will address the operating environment and aviation infrastructure, weather observations and recording, airport condition reporting, and adequacy of the current instrument flight rules system.

2.7 Summary

This architecture is a joint plan of the FAA and NAS users on how to modernize the NAS. Today's NAS, while safe and efficient, can be improved significantly through use of new technologies and operating procedures. Successful modernization depends on effective continuous FAA and NAS user planning as well as their mitigation of the risks of new technology.

This document describes how the NAS will evolve consistent with the *Government/Industry Concept of Operations* and the FAA's *A Concept of Operations for the National Airspace System in 2005*.

2.8 Detailed Comments on Architecture 98 From RTCA Free Flight Select Committee

The following pages present the RTCA Free Flight Steering Committee letter and comments on the draft Architecture 1998.

RTCA

RTCA, Inc.
1140 Connecticut Avenue, N. W., Suite 1020
Washington, D. C. 20036

Telephone 202-833-9339
Facsimile 202-833-9434

December 10, 1998

The Honorable Jane Garvey
Administrator
Federal Aviation Administration
800 Independence Avenue
Washington D.C. 20591

Dear Mrs. Garvey,

The Free Flight Steering Committee applauds the FAA's substantial effort to develop and document a single, coherent plan for NAS modernization. As we all agree, the main purpose of this architecture is to document a plan on which both the FAA and the users can base investment decisions. We encourage the FAA to publish Architecture 4.0, thereby setting the baseline for managing NAS modernization activities and reaping the many programmatic benefits that will accrue therefrom. We also encourage FAA to continue working closely with the entire aviation community to move the very important modernization effort forward.

A number of themes emerged as we consolidated our views about the architecture. They are captured in the attachment, along with more detailed comments and concerns about selected sections of Part III, NAS Architecture Description. As a way to underscore FAA's past and continuing commitment to modernizing the NAS as a collaborative, government / industry endeavor, we request that you include this letter and the attachment as part of the published architecture package.

We appreciate the opportunity to work closely with your management team to address the issues we have identified. This collaboration will greatly enhance our collective chances of success. We recognize that such a process is new to all of us and creates new institutional challenges for you. We take our role seriously and will remain responsible and constructive in our feedback.

Sincerely,

Robert Baker
Co-Chair
Free Flight Steering Committee

Monte R. Belger

Monte Belger
Co-Chair
Free Flight Steering Committee

Attachment
Detailed Comments on Architecture 4.0

"Requirements and Technical Concepts for Aviation"

Detailed Comments on Architecture 98 from
RTCA Free Flight Select Committee

A number of themes emerged as the RTCA Free Flight Select Committee reviewed and consolidated comments into a single package. They are presented below:

1. The steps in the plan need to be more benefits-driven. Motivation for user equipage, for example, is not addressed adequately. The document should describe the link between each increment of operational capability and enabling technologies and its associated benefits.
2. Issues related to transition from one step to the next, such as mixed equipage, are not addressed adequately. It is difficult to discern a series of discrete steps from this document. The architecture does not define activities necessary to move between consecutive steps.
3. The architecture should acknowledge throughout, where appropriate, that lessons learned from ongoing experiments and initiatives (e.g., Safe Flight 21) will be integrated into the architecture and will drive technology and other related decisions.
4. The year 2005 needs to be defined as a milestone, describing all components that will be in place. This description should match the FAA and the Government/Industry Operational Concept for 2005. Further, the FAA should continue to apply beyond Free Flight Phase 1 the evolutionary development paradigm that industry / RTCA has recommended.
5. A chapter on Airspace should be included. Airspace is a critical national resource that must be optimized in order for the NAS to gain full benefit from programmed infrastructure enhancements, emerging technology initiatives, and procedural changes that support the transition to Free Flight.
6. The relatively high risk of implementing automation (hardware and software) infrastructure is not addressed adequately.

Following is a list of more detailed comments about selected sections of the Architecture.

SECTION 15 - Navigation and Landing
- Architecture should clarify how phasing down of ground navigation aids will be accomplished
- Sole means issue should be resolved and policy documented in the architecture

SECTION 16 - Surveillance
- Policy should be clearly stated
- Transition path is not clear and needs to be described
- Architecture should address how a mixed equipage environment will operate, and how users will be motivated to equip
- Technology decisions, such as Mode-S, should be based on the results of the RTCA Surveillance subgroup and of Safe Flight 21.

SECTION 17 – Communications
- Architecture should acknowledge that industry is on record as not endorsing VDL Mode 3
- Architecture should acknowledge the CDPCL Build 1 program and describe how lessons learned will be incorporated into the NAS

SECTION 18 - Avionics
- Human factors, certification, equipage and transition issues are not adequately addressed

Detailed Comments on Architecture 98 from
RTCA Free Flight Select Committee

SECTION 19 - NAS Information Architecture
- Architecture should acknowledge that NAS Information Architecture encompassed more than CDM
- Data ownership and security issues should be addressed, and FAA policy stated

SECTION 20 - TFM
- Architecture should clearly distinguish TFM from NAS Information Architecture and CDM
- Architecture uses CTAS terms interchangeably. It should include clear definitions of the following terms/programs: CTAS, TMA, pFAST.

SECTION 21 - En Route
- Incremental, evolutionary development should be incorporated as the basic development philosophy so that enhancements of both capabilities and infrastructure can be adequately addressed.

SECTION 22 - Oceanic
- Architecture should acknowledge alternative acquisition strategy being considered for the ocean.

SECTION 23 - Terminal
- Architecture should acknowledge that STARS is a major risk area, and should define a risk mitigation strategy
- Architecture uses CTAS terms interchangeably. It should include clear definitions of the following terms/programs: CTAS, TMA, pFAST.

SECTION 24 - Tower/Surface
- Architecture should acknowledge the Safe Flight 21 Program, and indicate that lessons learned in ADS-B experiments will be fed into the Architecture.

SECTION 25 - Flight Stations
- Architecture should better define transition benefits and the role of the private sector in the evolution of Flight Service Station Services.
- It should be clearly stated what role commercial services are to play in providing weather data

SECTION 28 - Airports
- Consider deleting this chapter. Most of what is covered is covered in other chapters on Terminal and Surface Operations. Other aspects of airports are outside the scope of the FAA's Architecture

PART II

NAS ARCHITECTURE

SUPPORTING ELEMENTS

3 PART II NAS ARCHITECTURE SUPPORTING ELEMENTS OVERVIEW

Part II and Part III describe the concept of how a modernized NAS would operate based on the principles published in the *Government/Industry Concept of Operations* and *A Concept of Operations for the National Airspace System in 2005* (referred to jointly as the CONOPS). A brief discussion of each section in Part II follows.

Based on the CONOPS, operations within the NAS will change as the NAS is modernized. Section 4, NAS Operations, summarizes the NAS architecture from the user/pilot perspective, with a generalized description of flight operations and potential user benefits in a modernized NAS.

To ensure safety, new capabilities will be implemented incrementally. Section 5, Evolution of NAS Capabilities, defines the three NAS modernization phases and summarizes the enhanced and new capabilities available to air traffic service providers and users. Appendix D provides detailed capability drawings and a matrix for each NAS modernization time period, by phase of flight.

The FAA recognizes that modernization has a variety of technology and acquisition risks. Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone, describes the programs that comprise the NAS modernization risk-mitigation effort. The programs evaluate new technologies and procedures in an operational environment to reduce implementation risks and identify user benefits. The results will serve as a basis for user/provider decisions on national deployment.

During NAS modernization, the FAA's highest priority is to ensure that the safety of the air traffic control system is improved. Section 7, Safety, describes how safety will be improved through incremental implementation of new systems, controller automation tools, and new cockpit avionics.

Because NAS operations are so complex, it is important, from a safety and workload perspective, to understand the human factors implications of changes to the NAS. Section 8, Human Factors, outlines the approach that will be used to: (1) develop or improve human interfaces with the system; (2) optimize human/product performance during system operation, maintenance, and support; and (3) make economic decisions on personnel resources, skills, training, and costs.

The FAA must maintain a system that includes both physical and information security. Section 9, Information Security, outlines the security issues and approaches required to protect new information-based systems while increasing data exchange with external users. This section also addresses the increasing dependence on commercial, "open" systems and the urgency of protecting NAS data availability, integrity, confidentiality, and authenticity. Physical security is an enabler of information security; Section 29, Facilities and Associated Systems, provides more information on physical security.

It is important for the FAA and the users to mutually understand the impact of emerging technologies before they are implemented. Section 10, Research, Engineering, and Development (R,E&D), describes the R,E&D program and its relationship to the NAS modernization process.

Standards and certification of new avionics, procedures, or systems is fundamental to maintaining the safety and interoperability of the NAS. Section 11, Regulation and Certification Activities Affected by New NAS Architecture Capabilities, discusses some of the FAA's processes used to carry out the regulatory and certification mission. This section contains a preliminary analysis of the regulations that will need to be revised and/or expanded to accommodate NAS modernization.

As in most major service organizations, personnel are the FAA's primary and most costly asset. Section 12, Personnel, discusses the costs and overall staffing levels by budget categories.

The overall resource requirements of a plan must be understood before it is implemented. Section 13, Cost Overview, discusses the costs associated with modernization for three types of funding: R,E&D; facilities and equipment (F&E); and operations (OPS). The costs associated with the Airport Improvement Program (AIP) are not addressed in the architecture at this time.

4 NAS OPERATIONS

This architecture is based on designing a NAS that provides the level of services set forth in the joint Government/Industry operational concept and the Air Traffic Services (ATS) concept of operations (referred to jointly as the CONOPS). Both concepts of operations were coordinated with the user community and take advantage of current and emerging technologies to advance NAS operations towards Free Flight. NAS efficiency is increased while safety is enhanced by incorporating new communications, navigation, and surveillance concepts with advanced automation that provides enhanced decision support tools. This section details the NAS evolution from its current state toward one of Free Flight.

4.1 Concept of Operations

The Government/Industry Select Committee for Free Flight Implementation prepared a report that outlines a user and service provider[1] program and delineates activities for implementing the concepts and capabilities of Free Flight. The report, *Government/Industry Operational Concept for Free Flight*, presents a joint perspective of the concept of operations (CONOPS)[2] and potential procedures and technologies for achieving these capabilities. It is intended to serve as the basis for an incremental and benefits-driven approach toward Free Flight. Free Flight allows aircraft operators to choose routes, speeds, altitudes, and tactical schedules in real time, thus improving air travel. Free Flight, which combines the flexibility of visual flight rules (VFR) with the safety (traffic separation capabilities) of instrument flight rules (IFR), will offer significant potential savings in both fuel and flight time.

The ATS CONOPS, described in *A Concept of Operations for the National Airspace System in 2005*, presents the service provider perspectives on NAS operations. It also incorporates International Civil Aviation Organization (ICAO) communications, navigation, and surveillance/aeronautical telecommunications network (CNS/ATN) concepts. By implementing these concepts, the NAS will evolve to meet user needs for greater flexibility and predictability and increased efficiency. Before this operational concept can be implemented, procedures and technologies must be further developed and validated, with an emphasis on human operator considerations.

The CONOPS proposes new or improved NAS capabilities and services, new facilities and equipment, and new roles for controllers, maintenance personnel, and managers. Understanding the capabilities and limitations of controllers, maintenance personnel, and pilots in current and future NAS configurations is critical to the success of the NAS modernization.

The CONOPS is the basis for procedural, investment, and architectural decisions on the operational capabilities and services required to achieve Free Flight.[3] These operational concepts are the first steps of implementing far-reaching concepts in the evolution toward a Free Flight environment and do not describe an end-state system.

4.2 Flight Planning

To support a strategic flight planning process, a NAS-wide information network must distribute timely and consistent information for both user and service provider planning. This information network will provide a greater exchange of electronic data and information between users and service providers—while simultaneously reducing workloads. The flight planning process will

1. The term "service provider" refers to anyone who provides separation assurance, navigation/landing services, aviation information, search and rescue, or other assistance to NAS users. The terms "user" and "NAS user" refer to anyone who uses the air traffic system, specifically air carriers, general aviation (GA), and the Department of Defense (DOD).
2. In the architecture, the term CONOPS applies to both the *Government/Industry Operational Concept for Free Flight* and Air Traffic Services *A Concept of Operations for the National Airspace System in 2005*. When a specific one is referred to, it is called out in the text.
3. Free Flight is defined as a "safe and efficient flight operating capability under instrument flight rules (IFR) in which the operators have the freedom to select their path and speed in real time. Air traffic restrictions are only imposed to ensure separation, to preclude exceeding airport capacity, to prevent unauthorized flight through special use airspace (SUA), and to ensure safety of flight." Restrictions are limited in extent and duration to correct the identified problem. Any activity that removes restrictions represents a move toward Free Flight.

PART II

be improved by exchange of current information about pilot intentions and airspace flow restrictions. This real-time information sharing will be available to users both on the ground and in the air, via data link. As conditions change during the planning phase or during flight, the pilot will be able to determine the actions required to safely continue to destination.

NAS-wide information sharing will allow increased collaboration between users and service providers for resolving strategic problems. For situations such as demand-capacity imbalances or adverse weather en route, this capability will support collaboration in determining when, where, and how to initiate a ground delay program or revise the route structure. Collaboration will increase the capability of users to minimize disruptions to their operations (see Figure 4-1).

Interactive flight planning will permit airlines to monitor their aircraft fleet activities during both routine and nonroutine (e.g., adverse weather) operations, allowing better use of resources as well as cost savings. Increasingly accurate data will be distributed simultaneously to service providers and all users. The data will include dynamic information, such as current and forecast weather, hazardous weather condition warnings, information on updated airport and airspace capacity constraints, and special use airspace (SUA) schedules.

Currently, most airline operations centers (AOCs) electronically auto-file flight plans directly to en route center host computers, while some air carriers file bulk-stored flight plans with each en route center. Individual flight plans are filed through the nearest flight service station (FSS).

Department of Defense (DOD) Base Operations file military flight plans through the FSS, or in some cases, military pilots file directly with FSS personnel. A significant portion of general aviation (GA) VFR pilots do not file flight plans and will not be required to do so. GA pilots, who do file flight plans, interact directly with flight service specialists to acquire preflight briefings, to file VFR or IFR flight plans, and to obtain inflight weather forecasts. GA pilots can file online rather than through the FSS by phone. Airborne pilots can file or change any segment of their flight plan by contacting air traffic control (ATC) or the FSS. Flight service specialists log flight plans into the ATC system via the host computer.

NAS modernization will expand user support and streamline the flight planning process. Today's process does not inform flight planners about existing and projected conditions in the NAS. The result is that the intended flight route may be altered by the tactical controller after departure. This increases both flight deck and controller workload. Interactive flight planning will increase user self-reliance for preflight services, but some level of flight service assistance will always be available to users (see Section 25, Flight Services).

To support improved planning capabilities, today's flight plan will be replaced by a flight profile. This profile can be as simple as the user's preferred path or as detailed as a time-based trajectory that includes the user's preferred path and preferred climb and descent profiles. The flight profile will be part of a larger data set called the flight object.

The flight object will be available throughout the duration of the flight to both users and service providers across the NAS. For an appropriately equipped aircraft operating under VFR, which has requested services from the FAA, the flight object may only contain the flight path, a discrete identification code, current location, and necessary information to initiate search and rescue.

For a flight operating under IFR, the flight object will be a much larger data set, including a preferred trajectory coordinated individually by the user and supplemental information, such as the aircraft's current weight, position, arrival and departure runway preferences, or gate assignment. Flight object information will be updated by the user and service provider throughout the flight.[4]

As the planner generates the flight profile, information on current and predicted weather conditions, traffic density, restrictions, and status of SUAs will be available to assist the planning. When the profile is filed, it will be automatically

4. The Flight object can be viewed as a discrete data file on the flight that is updated periodically and passed on by the NAS information network to service providers, as needed, to support that flight.

checked against these conditions and other constraints, such as terrain and infrastructure advisories. The operational reasons for requesting modifications or rejecting the flight profile will be

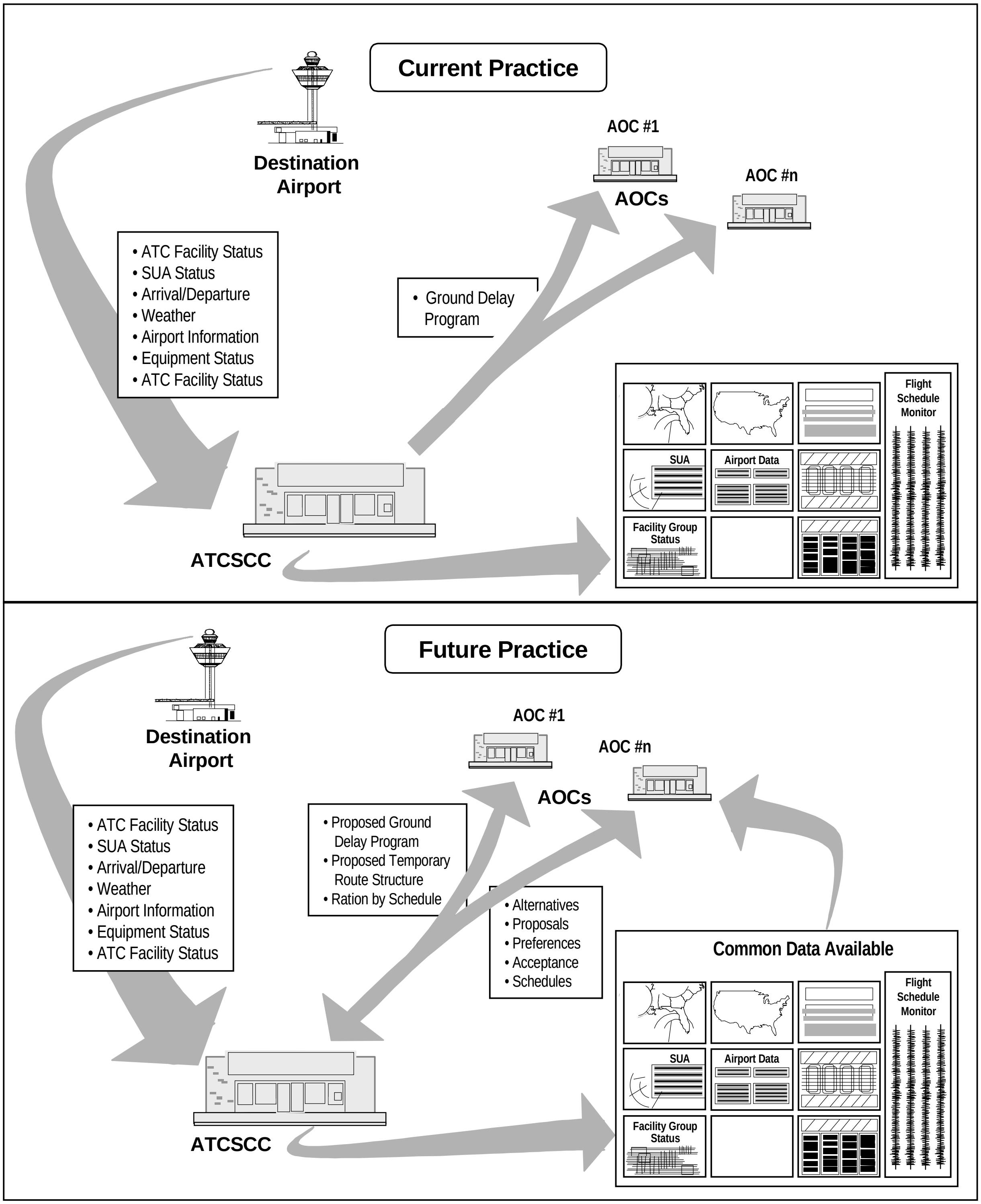


Figure 4-1. Collaboration and Information Sharing

As information sharing increases between NAS users and operators, collaboration will increase, and commercial aviation will be allowed greater control in making decisions that affect operating costs.

transmitted to the planner. After approval, the profile will be automatically distributed to service providers who will monitor the flight.

Information sharing will increase over time. Initially, data exchange between AOCs and the FAA will be the focus. As the flight object becomes more prevalent, the information available to all NAS users will be expanded to include time-based planned trajectory by flight. As information sharing and collaboration increase, NAS users will have greater influence on decisions that affect operating costs.

4.3 Airport Surface Operations

Separation of aircraft in the airport surface movement area is the responsibility of the airport traffic control tower (ATCT) (see Section 24, Tower and Airport Surface). The ATCT is also responsible for separating aircraft arriving at or departing from the airport and provides approval for vehicles to operate on airport runways. Other responsibilities include relaying IFR clearances, providing taxi instructions, and assisting airborne aircraft within the immediate vicinity of the airport (see Figure 4-2).

At today's busiest airports, surface operations often experience long delays. During low-visibility weather conditions, airport operations are dramatically slowed. Because communications are conducted via radio, frequency congestion can increase the possibility of missed instructions or confusing directions. NAS modernization will provide more efficient and safer surface operations for aircraft moving on runways and taxiways.

Users and service providers will derive significant benefits from new capabilities that improve low-visibility surface operations, taxi sequencing and

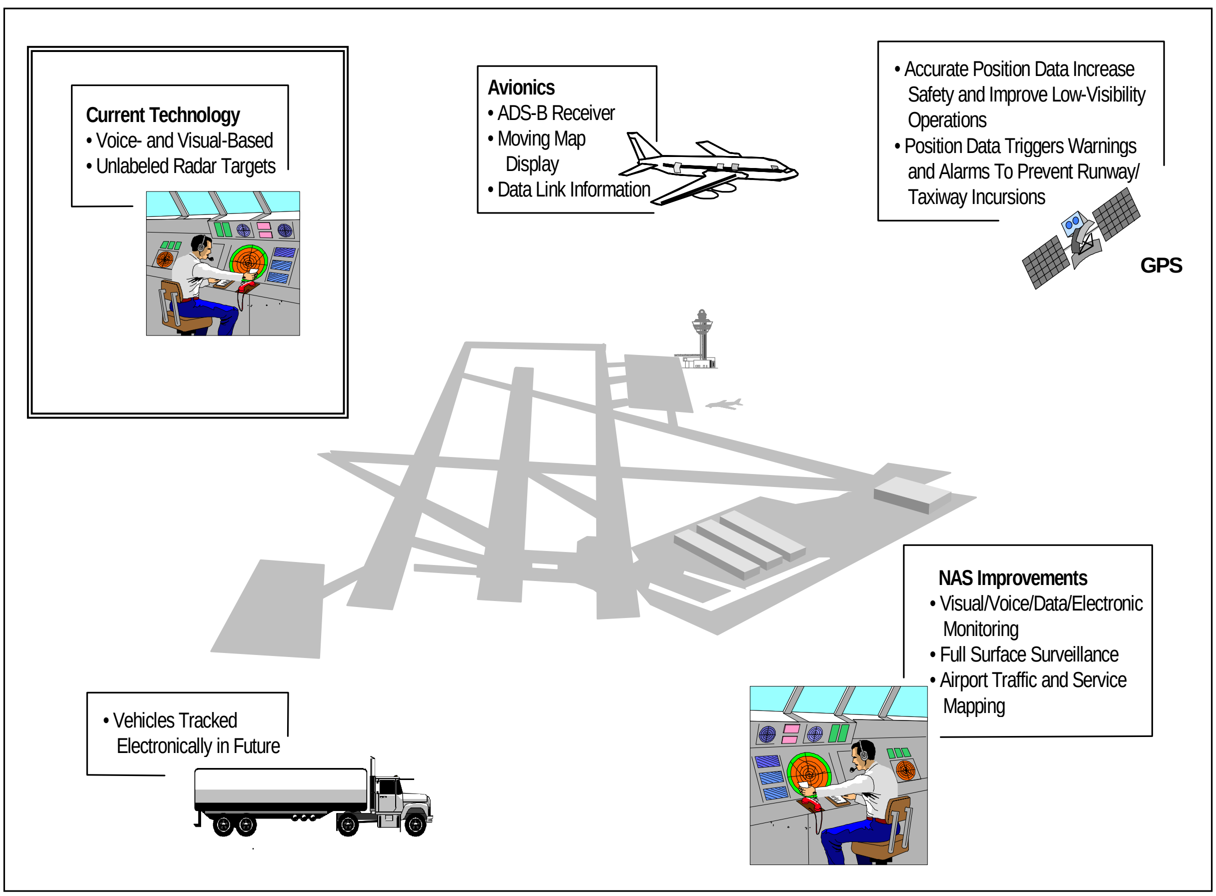


Figure 4-2. Improved Surface Operations

Improved surface operations reduce the impact of low visibility at the airport. As avionics and controller tools improve, weather-imposed delays will be minimized.

spacing, and weather and traffic situational awareness[5] in both the tower and cockpit. Faster and more reliable user/provider communications will also be realized. The use of satellite-based navigation and automatic dependent surveillance technology, updated cockpit avionics, and data link will provide the means for safer and more efficient low-visibility surface movement of aircraft and ground vehicles. These improved technologies will reduce the impact of low visibility on airport operations (see Figure 4-3).

New traffic situation displays will allow pilots, service providers, and ground vehicle operators to maintain situational awareness of all moving aircraft and vehicle traffic in their areas. This will help pilots follow taxi instructions and ground vehicle operators avoid conflicts with aircraft. Taxi operations will be possible in lower runway visual range (RVR) conditions than are possible today, reducing systemwide delays caused by weather.

Automated conflict detection and surveillance of airport movement areas, runways, and surrounding airspace will allow service providers to monitor traffic and be alerted to possible runway incursions. These capabilities will increase safety and airport capacity, and reduce taxi delays.

Surface movement decision support systems will save time and fuel by identifying the most efficient taxi sequence and routes appropriate to the departure and arrival activities. The NAS-wide information network will provide timely information about flight routes, traffic congestion, weather conditions, and destination airport operational conditions. Safety will be enhanced by reducing time between deicing operations and departures.

4.4 Terminal Area Operations

The Terminal Radar Approach Control (TRACON) provides separation and sequencing of aircraft in the terminal airspace (see Section 23, Terminal). Current TRACON operations consist mainly of standard departure and arrival routes coupled with radar vectors.[6] To improve traffic flow, departing aircraft are often vectored off the standard departure course until they can safely resume navigation along their filed route. The arrival sequence is established by vectoring aircraft and instructing them to begin descent, sometimes well before the terminal area, which results in excess fuel consumption.

NAS modernization—with augmented satellite-based navigation, automatic dependence surveillance, data link, and fully automated traffic flow management technologies—will support more flexible use of terminal airspace. Augmented satellite-based navigation will increase the number of runways available for IFR operations by providing precision approach capability to runways that lack this capability today.

Satellite-based navigation and automatic dependence surveillance will be used to establish low-altitude direct routes apart from the normal arrival and departure flows for each runway configuration used by airports. The low-altitude routes (including vertical flight) will support a segment of the user community that flies short routes between major terminal areas, providing reduced flight mileage, fuel consumption, and flight times.

Current arrival and departure procedures are based on flying fixed ground site radials (course) or distances, which are often oriented away from the destination airport. Many current arrival and departure procedures require aircraft to switch between ground navigational aids (Navaids) during critical phases of flight. Preferential arrival and departure procedures will be developed using the new capabilities inherent in satellite-based area navigation. Satellite-based navigation routes and approaches will be based on an earth geo-coordinate system that will provide accurate aircraft positions in relation to desired flight paths. This will allow aircraft to use a greater portion of the airspace around airports, increasing terminal airspace capacity.

New cockpit and ground system technologies will work together to improve traffic flow. The current practice of allowing pilots to maintain aircraft-to-

5. Situational awareness is knowledge about one's surroundings and intentions. Any improvements that can be made to increase a pilot's situational awareness will have a direct effect on increased safety and operational efficiency. Flight management systems, data link, heads-up displays, and multiple-function cockpit displays will assist in improving pilot situational awareness, providing that adequate human factors work is incorporated to prevent information overload.

6. A vector is a heading issued by controllers.

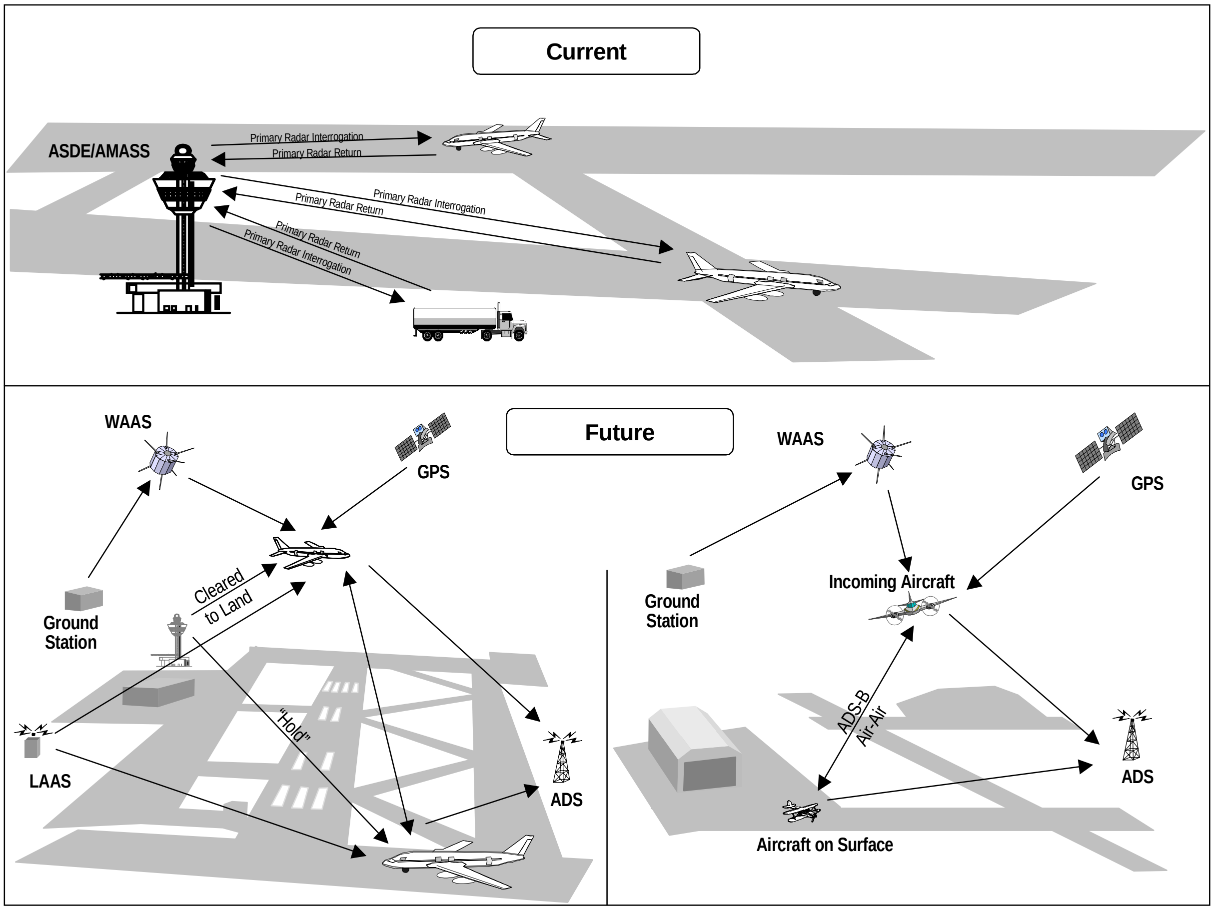


Figure 4-3. Improved Surface Movement Detection

As ADS-B equipage increases, smaller airports will benefit from better awareness of the location of aircraft and airport traffic, thereby reducing the potential for runway incursion incidents.

aircraft separation during visual weather conditions will be extended to instrument weather conditions, using cockpit display of traffic information (station-keeping), when operationally appropriate. Automated decision support tools will assist controllers in integrating departures with arrivals. Time-based metering techniques will be used to sequence and merge arrivals in accordance with users' preferences. Computerized conflict detection and resolution tools will allow service providers to monitor arrival and departure paths throughout the terminal airspace.

New terminal arrival/departure routes, based on satellite navigation, will reduce the number of vectors to airport areas. Users will receive the most expeditious route to the airport, but some radar vectoring or speed control will still be necessary to merge aircraft onto final approach. Airport capacity will be increased during instrument weather conditions by using simultaneous approaches to closely spaced parallel runways. Controllers who monitor precision approaches will be assisted by automation systems that more accurately track aircraft and calculate closure rates, vector geometries, and wake turbulence. Users will monitor adjacent traffic via cockpit display information, which will augment visual separation (see Figure 4-4).

New terminal procedures, cockpit avionics, and improved navigation and automatic dependence surveillance capabilities will enable aircraft to fly optimum climb and descent profiles. Departing aircraft will be able to fly optimum climb profiles, conserving fuel and reaching cruise altitude sooner. Arriving aircraft will remain at cruise altitude and begin descent closer to the airport. Exposure to lower-performance aircraft in low altitudes will be reduced.

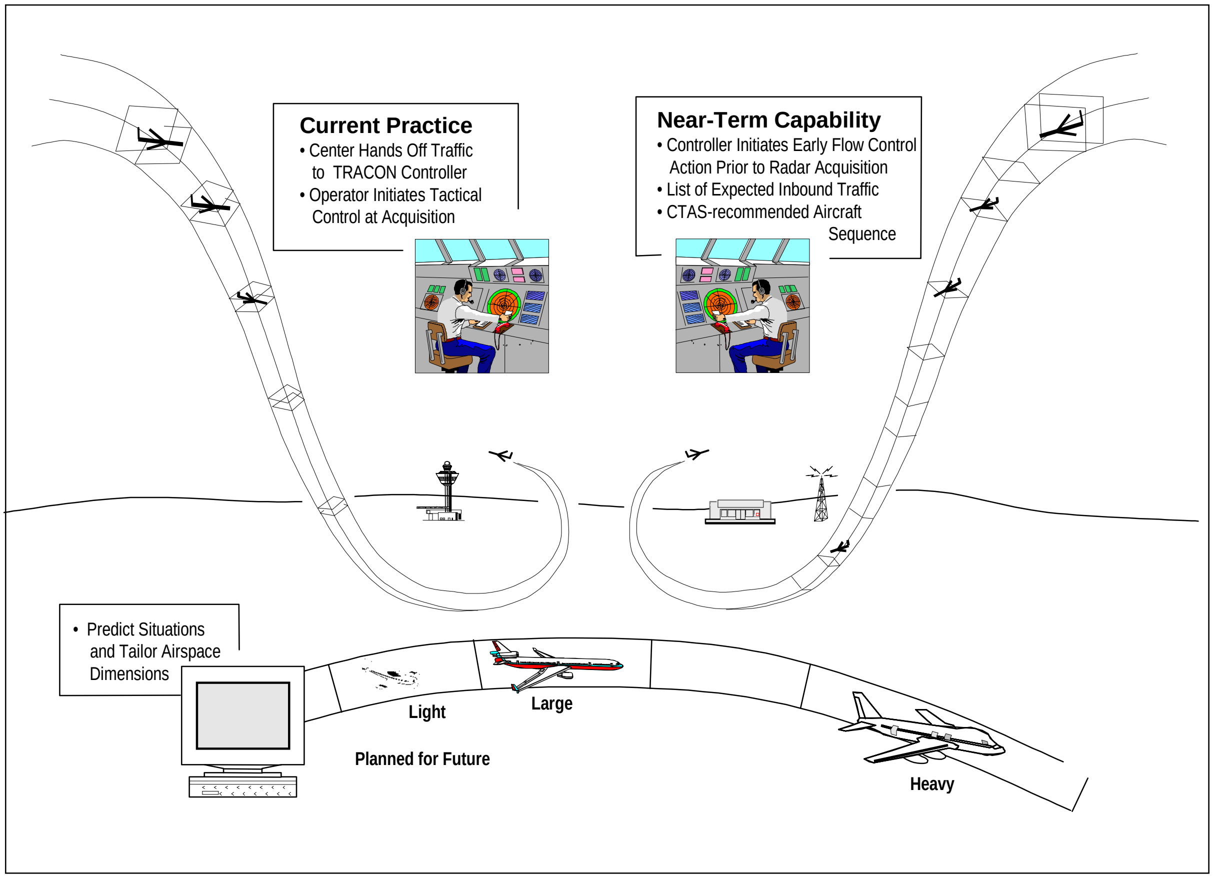


Figure 4-4. More Efficient Operations for Arrivals and Departures

Improved arrival and departure sequencing enables more planes to land or leave an airport during peak operating hours. This will alleviate the need for new runways at some airports.

Airport information, including weather reports, will be sent via data link to arriving aircraft approaching terminal areas. Data link will enable controllers and pilots to communicate using direct, addressed messages in conjunction with current voice radio communications. A direct benefit will be increased availability of voice communications channels. Data link is also expected to reduce the incidence of misinterpretation and operational degradation due to radio transmission blocking.

As satellite-based navigation augmentation is implemented, satellite precision approaches will become available throughout the NAS. This provides instrument precision approaches to many airports that currently do not have this capability. This will relieve some of the traffic congestion at major hub airports during IFR operations, easing the workload on both pilots and controllers, while allowing expanded use of other airports. The availability of additional precision approaches will provide an important safety benefit for a large segment of the aviation community and allow increased service to a greater number of airports.

4.5 En Route (Cruise) Operations

Air route traffic control centers (ARTCCs) provide en route ATC services through a ground-based network of radars, communications, and automation systems. Existing decision support tools for en route service providers are limited.

Evolving digital technologies, coupled with satellite-based navigation, automatic dependent surveillance capabilities, and cockpit avionics, will improve the way en route air traffic is managed in the future (see Section 21, En Route). Pilot situational awareness will be increased through improved cockpit avionics. The avionics will display critical flight safety information, such as weather, nearby traffic, terrain features, SUA status, notices to airmen, and significant weather advisories. Cockpit displays of real-time weather, such as heavy rain, lightning, and other thunderstorm activity, will assist pilots in avoiding hazardous conditions, thereby increasing flight safety.

Increased air traffic situational awareness of users and service providers will allow pilots to assume more responsibility for separation, routes, altitudes, and airspeed (i.e., Free Flight). The ability of air crews to dynamically select optimum routes, altitudes, and speed will be enhanced by improved communications, navigation, and automatic dependent surveillance technologies. This saves time and fuel, enabling users to make more cost-effective decisions and increasing the NAS flexibility.

Air traffic management procedures will incorporate advanced decision support tools to ensure positive separation of aircraft, while allowing maximum aircraft performance and flight path flexibility. The en route automation systems will enable a more flexible structuring of airspace and reduce current boundary restrictions. The airspace structure will be evaluated and adjusted, as necessary, to handle the demands of traffic flow or in response to weather conditions, and SUA and other NAS operational restrictions. Most en route communication and reporting will be done via data link, leading to faster and more reliable information exchange and allowing crews to more efficiently perform route and altitude planning (see Figure 4-5).

Some of the existing Navaids and airway route structures will be decommissioned consistent with the performance of satellite navigation. Routes will be retained to manage continuous high-traffic densities, terrain separation, and SUA, and to facilitate transition between airspace

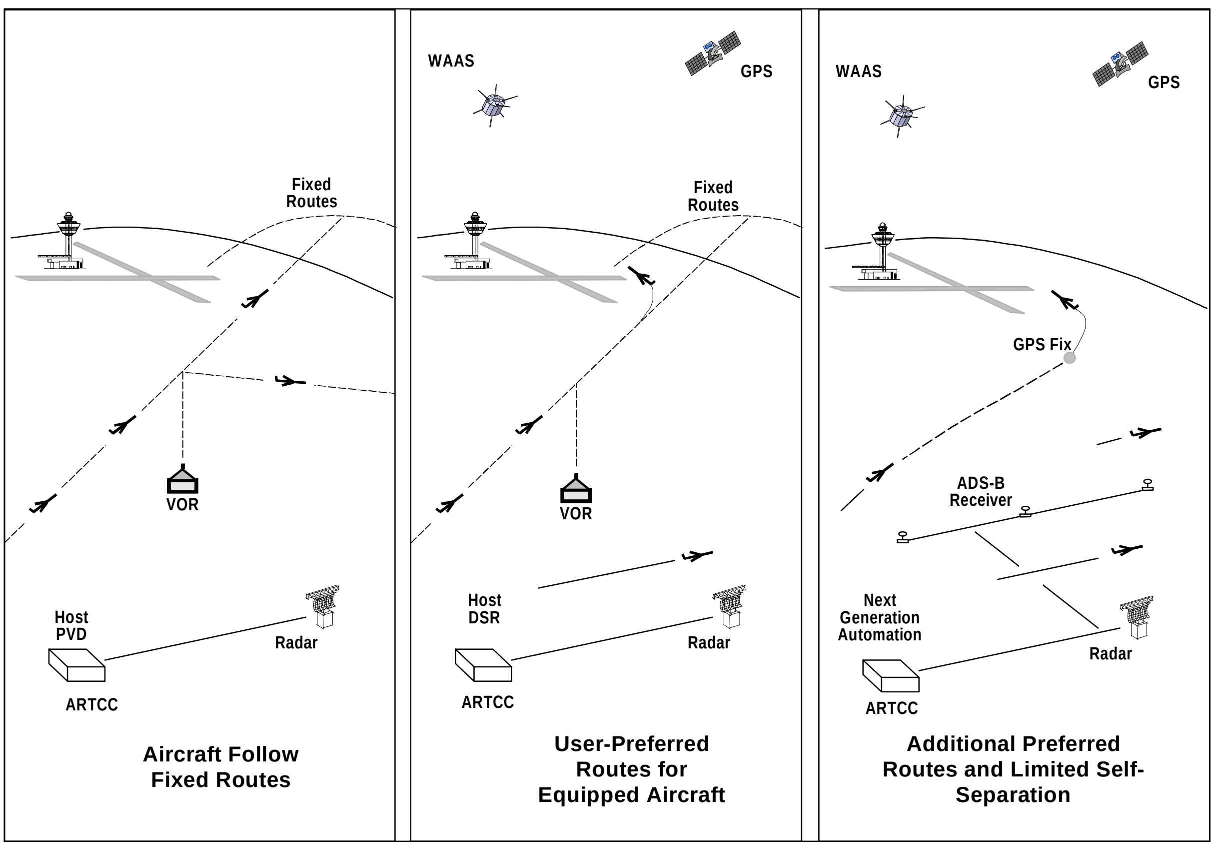


Figure 4-5. Aircraft Fly Preferred Routes

Enhancement in en route navigation and surveillance will allow users to fly preferred direct and wind-aided routes more often. This saves time and fuel, enabling users to make more cost-effective decisions and increasing the flexibility of the NAS.

with different separation standards. En route low-altitude direct routes will be implemented so that regional, business, GA, and other users whose aircraft operate most efficiently in low altitudes can benefit from Free Flight. Satellite-based navigation and procedural changes will enable lower-performance aircraft to fly desired routes at altitudes that are optimum for fuel consumption and cruise speeds.

Broadcast and processing of aircraft position and speed using automatic dependent surveillance will support air traffic services in areas not covered by ground-based radar. More accurate barometric altitude reporting will enable vertical separation above 29,000 feet to be reduced. The new capabilities, when available, will allow users to fly optimal altitudes and flight paths, thus reducing flight times and fuel consumption. A global grid of locations, defined by latitude and longitude coordinates, will augment the remaining fixed IFR routes. These grid locations will be used to define routes and transition points.

4.6 Oceanic Operations

Currently, en route and oceanic facilities are co-located in ARTCCs, but do not share communications or automation systems. In addition, oceanic controllers rely upon pilot voice position reports via high-frequency radio. The vast oceanic airspace has no ground infrastructure of Navaids or VHF radio communications. This unique operating environment has forced the en route and oceanic domains to evolve separately. As the capabilities in aircraft and on the ground improve, en route and oceanic cruise operations will become increasingly similar.

Today's oceanic operational capability is constrained by lack of surveillance, poor communications, and limited controller automation tools. Oceanic service providers use "time and distance" separation procedures based on periodic aircraft position reports relayed by a commercial service provider to oceanic ATC facilities. Some specially equipped aircraft (with the future air navigation system (FANS-1/A)) fly flexible tracks in the Central Pacific that reduce distance, separation, flight times, and fuel consumption.

Oceanic aircraft are equipped with the latest navigation avionics, such as GPS receivers and inertial navigation systems (INS), to compensate for the lack of ground-based navigation systems. In-trail climbs and descents are now available for aircraft equipped with the Traffic Alert and Collision Avoidance System (TCAS), allowing greater fuel efficiency and flexibility.

Cockpit traffic display avionics will extend pilot situational awareness. Automatic dependent surveillance broadcast (ADS-B) is expected to provide additional operational gains by allowing oceanic aircraft to laterally pass other aircraft at the same altitude by establishing an aircraft offset track. Using cockpit displays, the pilot will be responsible for maintaining minimum lateral separation from other aircraft and rejoining the original flight track (see Figure 4-6).

Oceanic operations will improve with NAS modernization (see Section 22, Oceanic and Offshore). Service providers will have a surveillance capability by means of automatic dependent surveillance addressable (ADS-A), and new automation displays. New advancements in ATC decision support tools, data link communications, surveillance, and navigation will facilitate merging domestic en route and oceanic control methods. As a result of these new capabilities, separation standards may be decreased, thereby increasing capacity.

Communications and coordination between users and service providers will be improved to a real-time capability by means of satellite communications (SATCOM) and/or high-frequency data link (HFDL). The FANS-1/A-based data link environment will evolve to one that includes ICAO/ATN-compliant communications and application services.

Any changes made to the NAS portion of oceanic airspace will be coordinated through ICAO. Coordination and information exchange between adjacent flight information regions (FIR) will be provided by interfacility data communications. Flight plans and flight progress information will be transmitted to adjacent FIRs in ICAO format.

4.7 Traffic Flow Management

Traffic flow management (TFM) optimizes airspace capacity for all phases of flight, based on demand and weather. The TFM system organizes traffic nationally and locally in order to balance

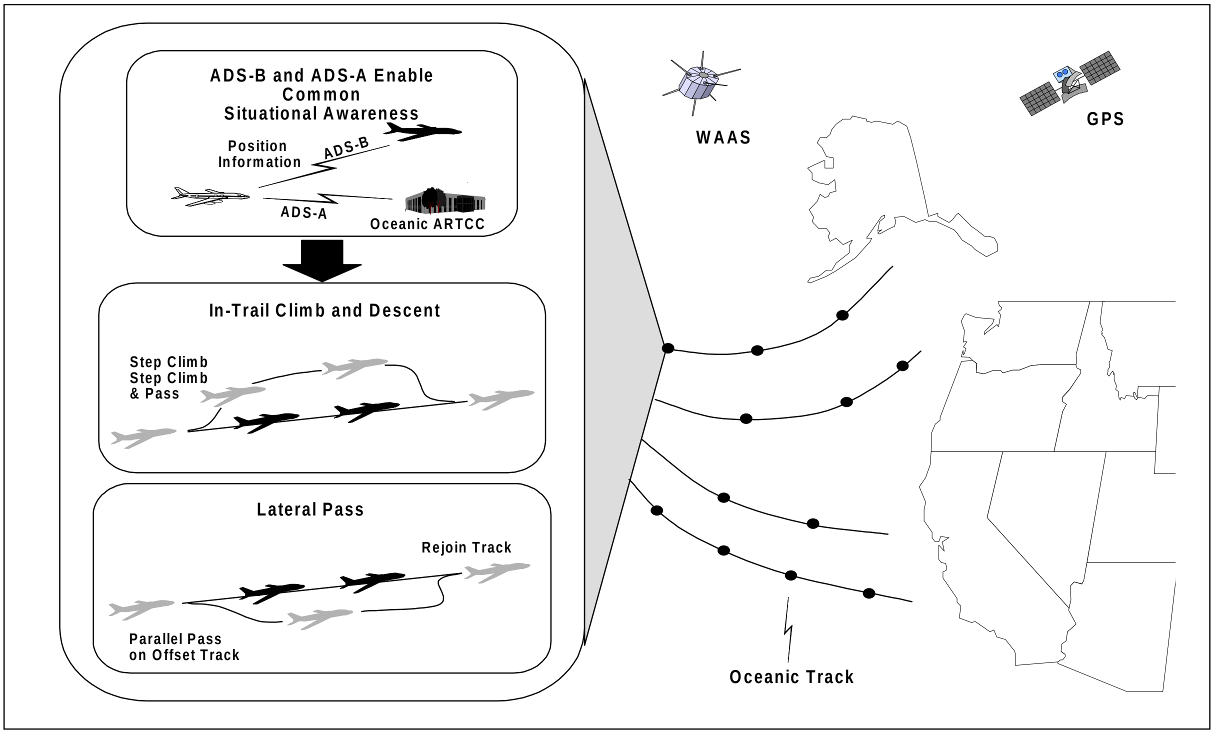


Figure 4-6. Improved Oceanic Operations

In oceanic environments, properly equipped aircraft will benefit from reduced separation standards. This will enable them to fly more wind routes and allow limited oceanic "passing" capabilities.

capacity and demand throughout the NAS (see Section 20, Traffic Flow Management). At airports, TFM determines and manages airport acceptance rates adjusted for winds, severe weather, runway configuration, operational factors, and equipment outage.

In the future, TFM, in collaboration with users, will employ both ground delays and airborne flight metering to manage traffic to meet the airport/sector acceptance rate. Instead of being assigned arrival slots at specific times for each flight, each user will be allocated a set number of arrivals within a specified time frame. Users will schedule departures to meet the designated arrival times.

TFM will monitor all SUA to identify availability of airspace for general use. Allocating inactive SUA to civilian users will optimize use of this shared resource. This requires strategic and tactical airspace management based on planned and actual movements of aircraft in real time.

To improve strategic planning, new tools will enable the FAA and users to evaluate operational activities at the end of each day. The tools will simulate the impacts of various decisions. In this manner, more efficient "game plans" between the FAA and the users will be developed. These strategic plans can then be implemented by NAS users and service providers to ensure that operations proceed smoothly and delays are minimized.

4.8 Managing the NAS Infrastructure

Many internal agency functions support the array of new technologies and operations that characterize the modernized NAS (see Section 27, Infrastructure Management). In the maintenance area, infrastructure maintenance activities will be monitored on a day-to-day basis. This service will be based on a national perspective rather than individual elements of the NAS infrastructure. It will increase the use of remote monitoring and control and facilitate collaboration between service providers and users, allowing users to participate in prioritizing scheduled and unscheduled repairs to essential NAS equipment.

4.9 Summary

NAS modernization emphasizes user benefits, technology insertion, and new procedures. The flight-specific and generalized operational descriptions are drawn from the anticipated flight operations, which range from clearance delivery to arrival at the destination airport using NAS enhancements derived from the modernization plans.

The essential focus is the Free Flight vision of a future NAS that permits users to fly without the constraints of today's structured routes and airspace. Air traffic restrictions are imposed to ensure separation, preclude exceeding airport capacity, prevent unauthorized flight through SUA, and ensure flight safety. This shift will be made possible by decision support tools for controllers, an enhanced pilot role in separation assurance using advanced cockpit avionics, use of space-based navigation aids, and use of a dynamic collaborative decisionmaking process. NAS modernization represents an approach that takes advantage of technology used in conjunction with new requirements and standards. NAS modernization will help the FAA operate more efficiently and enable the agency to be more responsive to user requests while maintaining the highest level of safety.

The current CONOPS is not an end state and it will be adjusted in collaboration with the user community as the NAS is modernized. The CONOPS will accommodate changes that will likely result from lessons learned from implementing new capabilities and potential benefits of new technology.

5 EVOLUTION OF NAS CAPABILITIES

5.1 Introduction

In each major operating area or domain of the NAS, new technologies and accompanying procedures and training will provide new capabilities to NAS users and service providers. This section presents an overview of these capabilities and presents illustrations that, taken together, provide snapshots of NAS modernization over the course of this architecture (1998–2015). A more detailed discussion and illustrations also appear in Appendix D. Figure 5-1 contains a chart of the modernization phases and the capabilities that will be implemented in each phase.

The schedule developed for delivery of the capabilities in the NAS architecture is constrained by the ability to transition to new technology in NAS operations and availability of funding. The resulting capability lists divide the implementation into three phases. Phase 1 covers 1998 through 2002, Phase 2 covers 2003 through 2007, and Phase 3 covers 2008 through 2015.

5.1.1 Phase 1 (1998–2002)

During Phase 1, current systems and services will be maintained while advanced services and upgraded systems are introduced. New technologies—such as the Global Positioning System and Wide Area Augmentation System (GPS/WAAS), User Request Evaluation Tool core capabilities limited deployment (URET CCLD), automatic dependent surveillance broadcast (ADS-B), and Center Terminal Radar Control Approach Control Automation System (CTAS) (consisting of the passive Final Approach Spacing Tool (pFAST) and traffic management advisor single center (TMA SC))—will be integrated through a logical series of changes.

Controller-pilot data link communications (CPDLC) implementation will begin a phased approach to develop en route aeronautical telecommunications network (ATN)-compliant data link services. CPDLC Build 1 and 1A will use very high frequency digital link (VDL)-2 for the air-ground subnetwork and will provide data link coverage to aircraft at 10,000 feet and above. However, voice communication will remain the primary method of information exchange during this period.

The principal goal of traffic flow management (TFM) is to increase airspace and airport capacity through strategic planning, tracking, and efficient tactical control of aircraft. TFM will focus on building collaborative decisionmaking support services that will allow the FAA to interact with airlines in real-time to resolve traffic congestion. Collaborative decisionmaking capabilities will be enhanced by ration-by-schedule and control-by-time-of-arrival capabilities, which will augment current ground delay procedures. Additionally, airline operations center (AOC) automation will be directly linked to FAA TFM to support real-time decisionmaking between airlines and the FAA.

The following activities will be included in Phase 1:

- Complete commissioning of airport surface detection equipment (ASDE) with the Airport Movement Area Safety System (AMASS)
- Implement the Traffic Information Service (TIS) on Mode-S to provide data link traffic information to pilots
- Deploy weather on display system replacement (DSR) to enable integration of next-generation weather radar (NEXRAD) weather information into en route controller displays
- Deploy ITWS stand-alone to selected airports
- Initiate use of flight information service (FIS) to the cockpit
- Implement multisector oceanic data link (ODL) at Oakland and New York facilities
- Upgrade the en route, oceanic, and the TFM systems
- Begin deploying the Standard Terminal Automation Replacement System (STARS) and DSR
- Begin deployment of Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD), including collaborative decision-making (CDM), initial surface movement advisor (SMA), URET CCLD, TMA SC, and pFAST

Phase 1	Phase 2	Phase 3
Continue NAS Modernization and implement limited Free Flight prototypes.	**Continue NAS modernization and begin transition to Free Flight.**	**Achieve Free Flight operations.**
Complete ATC DSS infrastructure sustainment and begin "opening" systems such as Host, STARS, and TFM. Collaboration between AOC's and ATCSCC is underway. Begin Installing new infrastructure to support more precise position reporting and less structured routes. FFP1 CCLD is deployed and procedural changes are made to enhance operations.	New "open" DSS system are installed, and new CNS infrastructure is being deployed. Free Flight concepts are implemented as procedural changes are made to take advantage of more collaboration with users.	New integrated ATC and TFM DSS tools allow greater sharing of 4-D flight profiles throughout the NAS, enabling greater flexibility and planning with users. Capacity is increased as more accurate position reports are incorporated onto DAA tools. Installation of CNS is completed.
Key Technologies •CPDLC •WAAS/GPS •URET CCLD •ADS-B Air-to-Air •pFAST •STARS	Key Technologies •Limited NEXCOM •WAAS/LAAS •ADS-B Ground Stations •ITWS •STARS P^{3}I •CP	Key Technologies •Full NEXCOM •Full CP •Next-Generation En Route Automation •aFAST/WV •NAS Info System
1998–2002	2003–2007	2008–2015

1998–2002			2003–2007			2008–2015		
Initial WAAS Cruise	URET CCLD (FFP1)	ITWS Stand-alone	LAAS Cat I	Conflict Probe	ADS-B Gap-Filler	Integrated Tower Area Surveillance	CPDLC Build 3 via VDL-Mode-3	NAS-Wide Data Link
ASDE with AMASS	Single Center Metering (FFP1)	Terminal Weather Exchange	LAAS Cat II/III	Improved En Route Surveillance (ASTERIX/SI)	Integrated En Route Surveillance with ADS-B	CPDLC Build 2 via VDL-Mode-3	NAS-Wide Information Sharing	Conflict Resolution with Multicenter Metering
Air-Air ADS-B	pFAST (FFP1)	Enhanced MDCRS	Oceanic surveillance ADS-A	Improved Weather on STARS	Integrated Terminal Surveillance w/ ADS-B	aFAST with Wake Vortex	Enhanced SMS	Interactive Airborne Refile
Initial WAAS Precision Approach	Multi-Sector Oceanic Data Link		Oceanic 50/50 nmi Lateral/Longitudinal Separation	Enhanced En Route Coverage	Multicenter Metering with Descent Advisor	Improved CDM for Maintenance Activities	ELT for SAR and Flight Following	Full CDM
			SMA					
	Initial FIS	Expanded TWIP	Improved Terminal Surveillance (ASTERIX/SI)	Flight Plan Evaluation	SMS			Automatic Simultaneous Hazardous Weather Notification
Initial SMA (FFP1)	CPDLC Build-1	Low Altitude Direct Routes - Using WAAS	Runway Incursion Reduction	Expanded TDLS Service	Low-Altitude Direct Routes - Expanded Radar Coverage			
Initial CDM (FFP1)		Terrain Avoidance	CDM for Maintenance Activity	CPDLC Build 2 via VDL-Mode-2	Low-Altitude Direct Routes - Expanded Surveillance Coverage			
Weather on DSR		CPDLC Build-1A						

Figure 5-1. Modernization Phases

- Begin initial collaborative decisionmaking between AOC and the air traffic control system command center (ATCSCC)
- Deploy initial WAAS navigation system
- Initiate use of ADS-B air-air for improved cockpit situational awareness
- Begin deployment of CPDLC Build 1 and Build 1A with ATN-compliant air traffic control (ATC) data link services (e.g., CPDLC) in en route airspace using VDL-2 for the air-ground subnetwork.

5.1.2 Phase 2 (2003–2007)

Phase 2 automation enhancements include upgrading and expanding CTAS, STARS preplanned product improvements (P^3I) development, and en route automation upgrades. STARS P^3I includes the capability to improve arrival traffic sequencing using time-based separation techniques.

Free Flight concepts will be implemented with procedural changes to take advantage of increased collaboration capabilities with users. CPDLC services will include Build 2 that provides International Civil Aviation Organization (ICAO)/ATN-compliant services using VDL-2 air-ground network. Build 2 will bring the Future Air Navigation System (FANS) and domestic CPDLC message sets closer together in format and capability.

The following activities will be included in Phase 2:

- Implement flight plan evaluation to increase collaboration with users
- Deploy surface management system (SMS) service provider tools to improve surface traffic movement operations
- Deploy runway incursion reduction at selected airports
- Implement improved weather data on STARS
- Transition to digital radios for voice in high-altitude en route sectors
- Provide 50/50 separation services to oceanic aircraft
- Deploy CTAS TMA multicenter (MC) and complete pFAST deployment
- Deploy conflict probe (CP) nationally
- Implement a new communication, navigation, and surveillance (CNS) infrastructure featuring the GPS, WAAS, and Local Area Augmentation System (LAAS), providing virtually universal navigational coverage and instrument approaches
- Begin implementing CPDLC Build 2 providing ICAO-ATN compliant services using VDL-2 air/ground network to provide data link services between users and en route facilities
- Accommodate both FANS-1/A- and ATN-equipped aircraft in oceanic airspace.[1]
- Begin using oceanic data link and automatic dependent surveillance (ADS) to reduce separation between suitably equipped aircraft flying oceanic routes
- Begin use of GPS/ADS-B data for surveillance service in nonradar and radar areas
- Implement Free Flight capabilities as procedural changes are developed.

5.1.3 Phase 3 (2008–2015)

Phase 3 automation upgrades will fully integrate all technologies into air traffic management. This phase will introduce the enhanced en route/oceanic system and full implementation of digital communications and air traffic planning tools that incorporate weather prediction and advisories. The oceanic and en route domains will employ similar procedures and separation methods.

Users will have the flexibility to file new, NAS-wide 4-dimensional flight profiles. This allows the user to meet any flight objective while providing maximum strategic planning for service providers. As the phase-in of new technology reaches completion, obsolete navigation systems will be phased down. Increased capabilities of the modernized NAS will eventually allow increased capacity utilization through VFR-like flight operations in IFR conditions.

1. Note that service-provider-operated communications services may be retained for data link that supports oceanic ATC operations and potentially as a backup capability in domestic airspace.

PART II

Maximum runway utilization rates, aircraft performance characteristics, and departure traffic schedules are balanced to produce a constant and efficient flow of arriving traffic to the runway. DSS tools will assist in determining the most advantageous descent point from cruise altitude, so each aircraft can fly the optimum descent profile for fuel efficiency. Airport, weather, TFM, and ATC system performance data will be available to aircraft via service provider data link.

The following activities will be included in Phase 3:

- Provide NAS-wide information sharing
- Provide interactive airborne refile to enable increased collaboration with users
- Provide integrated tower area surveillance for tower and surface
- Deploy enhanced SMS to fully integrate operations between surface and arrival/departure operations
- Deploy aFAST with wake vortex at TRACONs
- Provide conflict resolution with multicenter metering to evaluate requested flight path amendments across center boundaries
- Deploy NAS-wide data link via full next-generation air-ground communication system (NEXCOM) and CPDLC Build 3 via VDL-Mode-3 at all high-altitude en route and high-density terminal and tower facilities
- Begin using 4-dimensional (longitudinal, lateral, vertical, time) flight profiles to enable greater flexibility and planning with users and providers
- Employ full use of digital communications for voice and data in the en route environment
- Provide common en route and oceanic services
- Conduct visual flight rules (VFR)-like operations under IFR conditions.

5.2 Capabilities Overview

5.2.1 Background

In 1997, a concept of operations for a new NAS air traffic control system was generated. Two documents were developed: the *Government/Industry Operational Concept for the Evolution of Free Flight* was developed by the FAA and aviation community through the RTCA. The RCTA concept provides a joint view of how service provider and user interact in the new NAS. The FAA's concept is consistent with this document. *A Concept of Operations for the National Airspace System in 2005*, generated by FAA Air Traffic Services and approved September 30, 1997, presents the operational concept for the NAS from the perspective of the service providers, including detailing how they interact with air traffic. Together these make up the NAS concept of operations for the future, commonly referred to as the CONOPS.

The CONOPS does not address all aspects of the NAS. It assumes that many current capabilities will remain in place and address only those services and capabilities that need to be changed.

The NAS architecture is derived from the requirements of the CONOPS, and the NAS modernization architectural diagrams show the functional decomposition of the NAS. These diagrams are the basis for more detailed engineering diagrams that describe the implementation of capabilities in terms of specific functions and systems, their interdependencies and interfaces.

5.2.2 Assumptions

The following assumptions were made to define the scope of the capabilities.

First, the capabilities addressed are derived from the CONOPS, which focuses on changing capabilities and assumes that existing capabilities not addressed will remain as they are today.

Second, functions are assigned to phases and addressed. It is not assumed that all sites, or even all geographic areas, of the NAS will have the capabilities by that time phase. The precise number of sites or geographic areas where the improvements will be in place has not been established. In some cases, single installations and prototype systems are included to better show the progress of the NAS modernization.

Third, aircraft equipage (i.e., data link, satellite navigation equipment, etc.) is not to be mandated. Traditional voice radios and ground-based navigation aids will be available far into the future. However, benefits from NAS modernization will be made available to aircraft commensurate with the avionics equipage of the aircraft.

Fourth, for the purposes of illustration, most capabilities have been depicted in five phases of flight. They are:

- *Flight Advisory/Preflight*: Includes flight planning and preflight and postflight coordination activities
- *Tower/Airport Surface*: Includes takeoff, landing, gate activities, and taxi and ramp operations
- *Departure/Arrival*: Includes climb-out, descent, approach, and other terminal operations
- *En Route/Cruise*: Includes all operations between and above terminal areas
- *Oceanic*: Includes oceanic and offshore operations.

5.2.3 Sample Illustration of NAS Capability Diagram

Top-level diagrams showing the major components and the data flows between these components are available for each capability identified in the NAS Modernization Capabilities matrix (see Figures 5-2 through 5-4). These diagrams illustrate the changes anticipated in the NAS during the modernization phases as well as various phases of flight on a capability-by-capability basis. Short textual descriptions follow each diagram to provide a clearer picture of what takes place during that phase.

The differences in the capability "Increased Navigation/Landing Position Accuracy and Site Availability" for two modernization phases for Arrival/Departure are shown in Figures 5-2 and 5-3. Figures 5-2 and 5-4 illustrate the differences in Phase 1 between en route/cruise operations and arrival/departure operations.

A complete set of diagrams addressing the changes in the NAS capabilities throughout NAS modernization is included in Appendix D. The systems engineering of all NAS capabilities is an ongoing process and the diagrams will be updated periodically.

These updates will be posted to the FAA Web site (http//www.faa.gov) as they become available.

PART II

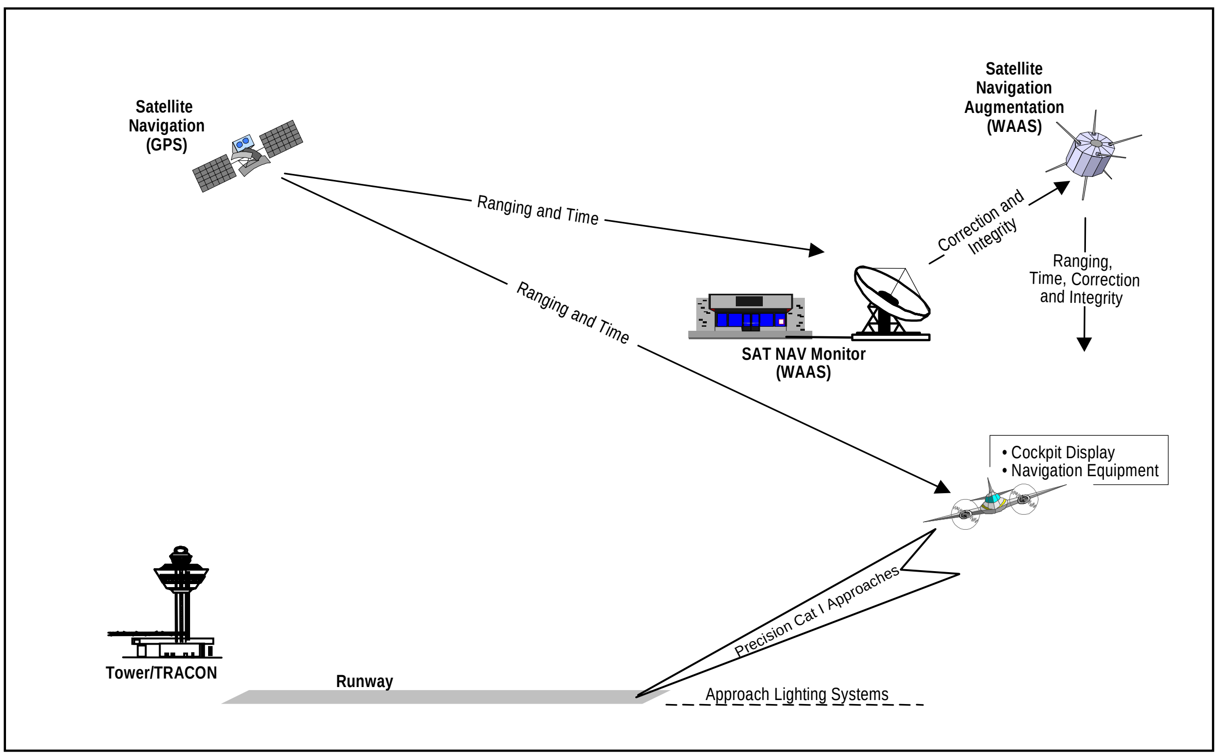


Figure 5-2. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services Arrival/Departure, Phase 1 (1998–2002)

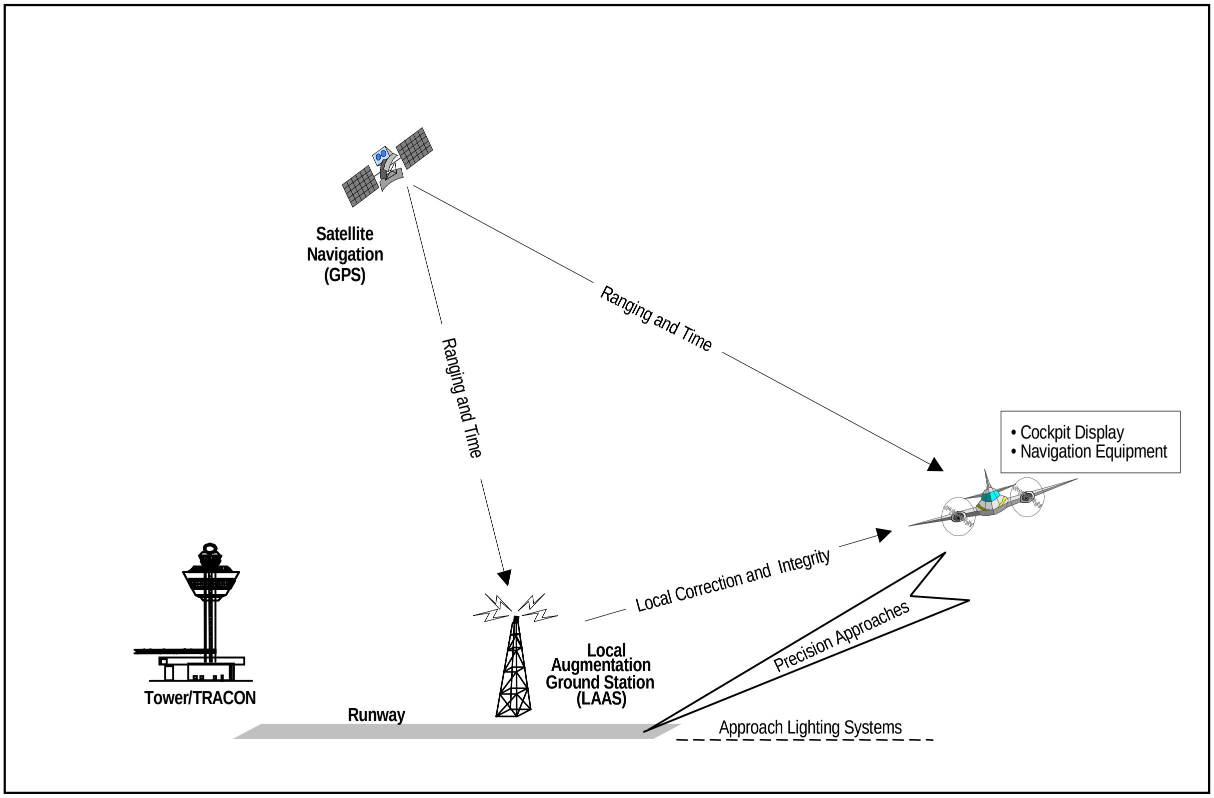


Figure 5-3. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services Arrival/Departure, Phase 2 (2003–2007)

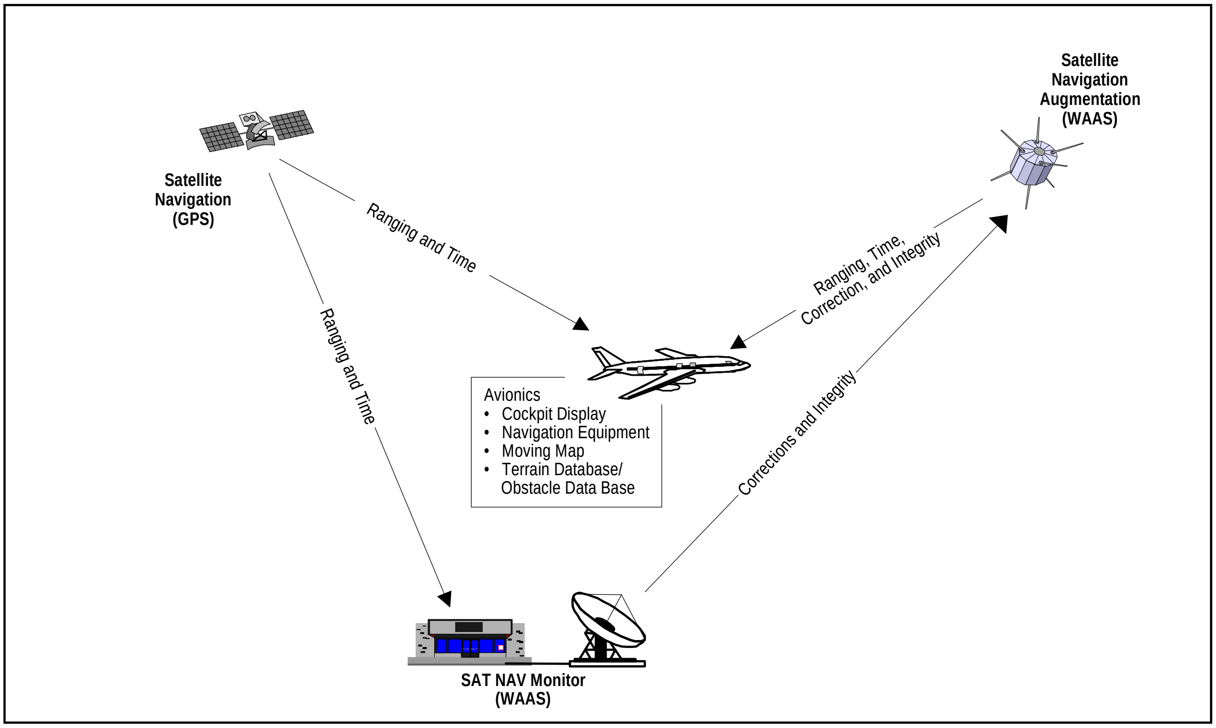


Figure 5-4. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services En Route/Cruise, Phase 1 (1998–2002)

Appendix D also contains a capability matrix, which addresses air traffic service capabilities throughout the active phase of flights and NAS management services that cross domains of flight or involve infrastructure management issues.

5.3 Summary

Viewing NAS modernization in terms of the capabilities provides insight into the complex integration that must be accomplished to advance the NAS towards Free Flight. New systems by themselves do not provide new services. Capabilities emerge only when combined with training, procedures, and certification/regulation, where applicable.

In the next section, risk management is examined. Many NAS modernization concepts have never been proven in operational use. Strategies to mitigate the risks of trying new technologies and procedures are discussed.

6 FREE FLIGHT PHASE 1, SAFE FLIGHT 21, AND CAPSTONE

The main objective of NAS modernization is to move the NAS toward a new type of flight operations known as Free Flight. Free Flight will allow pilots to change routes, speeds, or altitudes, as needed, while in en route and oceanic air space. Air traffic controllers will not impose restrictions on pilot-initiated changes, except when there is potential conflict with other aircraft or special use airspace (SUA). This capability will allow pilots to fly optimized profiles, the most efficient cruise speeds, wind-aided routes, and arrival descent profiles. Any activity that removes operational restrictions is a move toward Free Flight.

Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) incorporates guidance provided by the NAS Modernization Task Force. FFP1 CCLD is intended to provide early user benefits and mitigate technical risk by implementing key automation capabilities at specific sites within the NAS, for evaluation by aviation stakeholders and FAA operators. The deployments will allow computer-human interface (CHI), training, and safety factors to be evaluated. After the FAA and the users have gained experience and evaluated the individual FFP1 CCLD capabilities, decisions will be made on whether to deploy them to additional locations.

Safe Flight 21 will effect integration of new technologies, systems, procedures, and training for pilots and controllers. Safe Flight 21 deploys and evaluates certain air traffic control systems and avionics that use new communications, navigation, and surveillance technologies in an operational environment. These new technologies include applications such as automated dependent surveillance broadcast (ADS-B) for air-air and air-ground surveillance, and flight information services via data link. Avionics, certification, and procedural development are cost and schedule risks that must be mitigated. Additionally, user benefits must be proven before avionics and associated ground equipment capital investments can be made.

The Alaska Capstone program will evaluate safety and efficiency improvements identified by the National Transportation Safety Board (NTSB). The project will focus on the aviation services, flight rules, and weather observations available to pilots operating in an aviation-dependent portion of western Alaska.

The following paragraphs describe the FFP1 CCLD, Safe Flight 21, and Capstone programs. These programs identify and resolve risks associated with the development and deployment of new operational tools and procedures, as well as those associated with training, human factors, and user acceptance. Additional details regarding the system and interface dependencies, on which these capabilities depend, can be found in the functional and domain sections of this document (Part III, NAS Architecture Description).

6.1 Free Flight Phase 1 Core Capabilities Limited Deployment Description

FFP1 CCLD will consist of limited deployment of controller automation decision support tools, communications, and traffic flow planning tools, which are a part of Air Traffic Management (ATM) capability. FFP1 CCLD will be deployed at selected air traffic control (ATC) facilities to obtain and evaluate early benefits to service providers and NAS users, leveraging proven technologies with procedural enhancements. FFP1 CCLD will employ an evolutionary approach to system development and deployment that maintains a high level of NAS safety. FFP1 CCLD capabilities will be deployed in phases rather than as fully mature capabilities. FFP1 CCLD is a part of NAS modernization activities and will require infrastructure support from the Host replacement, the display system replacement (DSR), and the Standard Terminal Automation Replacement System (STARS), as well as other systems and programs. FFP1 CCLD components are:

- Conflict probe (CP), as represented by the User Request Evaluation Tool core capabilities limited deployment (URET CCLD)
- Center TRACON Automation System (CTAS) Traffic Management Advisor Single Center (TMA SC)
- Passive Final Approach Spacing Tool (pFAST)
- Collaborative decisionmaking (CDM) with airline operations centers (AOCs)
- Initial Surface Movement Advisor (SMA).

Conflict Probe (URET CCLD). This capability will be added at the DSR D-side (nonradar controller) position. URET CCLD's planning capability allows the D-side controller to manage en route user requests by identifying potential air traffic conflicts. It systematically checks for conflicts between aircraft (20-minute look-ahead) and between aircraft and SUA (40-minute look-ahead). If a conflict is detected, URET CCLD will provide the D-side controller with a visual indication of the problem. Updated SUA status will be available, and URET CCLD will automatically check flight trajectories against those data to determine if an airspace conflict exists.

CTAS TMA SC. This tool will calculate meter fix crossing times for all inbound aircraft to destination runways within air route traffic control center (ARTCC) airspace. CTAS TMA SC capability will operate on the radar controller's display and in the traffic management unit. It will provide controllers with the capability to develop arrival sequence plans for selected airports and will assign aircraft to runways to optimize airport capacity. The CTAS TMA traffic management tool computes an aircraft's estimated time of arrival. It assigns a scheduled time of arrival, outer meter arcs, meter fixes, and final approach fixes for each aircraft to meet the flow constraints established by traffic management coordinators. The meter list is available to the terminal radar approach control (TRACON) facility for monitoring the final approach fix and runway threshold sequencing when the aircraft is in TRACON airspace.

CTAS pFAST. This tool adds a new capability that assists controllers to optimally merge and sequence aircraft and assign runways according to user preferences and system constraints. It maximizes runway acceptance rates and meets user needs for operational efficiency in congested terminal airspace areas. pFAST uses flight data, track information, and controller inputs to generate a set of trajectories that form the basis for computed runway assignments. The trajectories also incorporate current weather conditions and aircraft flight characteristics. The scheduled time of arrival to the assigned runway final approach fix and runway threshold is then assigned. The pFAST display will enhance controller situational awareness, especially during heavy traffic operations.

CDM. Development and deployment of this capability will focus on building automation tools that will allow the FAA and the airlines to coordinate system resources in real time in response to airspace conditions. The three tools, Enhanced Ground Delay Program, NAS Status Information, and Collaborative Routing, will provide users and service providers with timely access to information. This information sharing will be the foundation of all collaborative efforts in NAS modernization. It will provide a common view of all NAS data and promote a cooperative effort to manage NAS traffic. Traffic flow managers' decisionmaking will improve because of the availability of better NAS user intent data, while NAS user decisionmaking will improve because of more timely and complete information on NAS operational status.

Initial SMA. This tool provides a one-way feed of arriving traffic information from the approach control automation system to ramp control computers for airline personnel use. Ramp controllers will use this information to plan and manage aircraft movement to/from gates and on ramp areas. This will improve gate operations and ground support services, resulting in a reduction of taxi times and takeoff delays.

The goal of FFP1 CCLD is to evaluate these automated decision support capabilities by the end of 2002 and begin national deployment during NAS Modernization Phase 2. FFP1 CCLD will not be a full-scale test of NAS modernization, but rather a limited test of decision support automation systems. The FFP1 CCLD program will be designed to derive early benefits from automation system upgrades as part of the larger NAS modernization program.

6.2 Safe Flight 21

The Safe Flight 21 project has replaced the Flight 2000 program. This government/industry initiative is designed to demonstrate and validate, in a real-world operational environment, the capabilities of advanced communication, navigation, and surveillance technologies, associated air traffic systems, and the pilot/controller procedures. Following are Safe Flight 21 capabilities and procedures, which constitute the means to move toward Free Flight.

- *Flight Information Services (FIS) for Presenting SUA Status, Weather, Windshear, Notices to Airmen (NOTAMs), and Pilot Reports (PIREPs) to Pilots.* Enhanced graphical and tabular information will be electronically transmitted to the cockpit. Data will be used to improve the content and timeliness of relevant flight planning information.
- *Controlled Flight Into Terrain (CFIT) Avoidance Through Graphical Position Display.* This will provide cost-effective terrain data in the cockpit to all airspace users for improved situational awareness.
- *Improved Terminal Operations in Low-Visibility Conditions.* This will provide improved situational awareness in the cockpit by using ADS-B position information of nearby aircraft. Data will be presented on a cockpit display of traffic information (CDTI) to enable the pilot to judge distance and speed of preceding aircraft in marginal weather conditions. This will yield benefits from increased arrival rates and access to airports.
- *Enhanced See and Avoid.* Integration of several communications, navigation, and surveillance (CNS) capabilities will be demonstrated to electronically provide improved traffic information to the pilot. Three ADS-B links with CDTI (1090 MHz, UAT, and very high frequency digital link (VDL) Mode-4) will be evaluated to determine which works best and is most compatible with the NAS infrastructure.
- *Enhance Operations for En Route Air-Air.* Use of ADS-B, CDTI, data link, and related technologies will be evaluated to examine the potential for delegating separation authority to the cockpit.
- *Improved Surface Navigation.* The capability of ADS-B, CDTI, and data link to improve the ability of the pilot to navigate on the airport surface in all weather conditions will be evaluated.
- *Enhanced Airport Surveillance for the Controller.* The enhanced information provided the pilot would also be provided to the controller through a digital data link. This information can be integrated with the radar data at airports equipped with ASDE surface radar.
- *ADS-B Surveillance in Nonradar Airspace.* Use of ADS-B will be examined in areas outside of radar coverage to allow controllers to provide separation services rather than procedural separation. Benefits expected would be increased safety, access to airspace, and route flexibility.
- *Establish ADS-B Separation Standards.* Integration and fusion of surveillance data from ADS-B and normal radar data will be tested for the possibility of reducing separation standards.

The Safe Flight 21 activity venues will include the Ohio Valley—with the Cargo Airline Association (CAA)—and in Alaska. The Safe Flight 21 project will focus primarily on developing a suitable avionics technology, pilot procedures for air-air surveillance, and developing a compatible ground-based automatic dependent surveillance system for ATC. The Ohio Valley venue of Safe Flight 21 will test three candidate avionics/data link technologies for air-air surveillance. They are the universal access transceiver (UAT), the self-organizing time division multiple access (STDMA) radio (also known as VHF data link-Mode-4, or VDL-4), and the Mode-S (1090 MHz) squitter.

The Ohio Valley venue will help test avionics, which periodically broadcasts the aircraft position (i.e., ADS-B), derived from the Global Positioning System/Wide Area Augmentation System (GPS/WAAS). These tests will occur in the terminal areas, which support cargo aircraft operations at Memphis, Wilmington, Louisville, Scott AFB, and Nashville. ADS-B-equipped aircraft will be able to receive the broadcast and display the position of other ADS-B-equipped aircraft CDTI. Pilots will use the CDTI display to:

- Identify and follow aircraft in the arrival pattern, thus maintaining higher arrival rates during reduced visibility conditions in the terminal area
- Provide situational awareness of the position of nearby aircraft.

The Ohio Valley project will also use GPS Local Area Augmentation (LAAS) avionics and the CDTI display with a moving map feature to help pilots taxi on the airport surface during reduced visibility conditions. GPS LAAS avionics will provide the precise navigation position required for arrival and surface operations. Vehicles that operate on the airport movement area will also be equipped with comparable equipment.

Finally, the Alaska portion of the Safe Flight 21 project will integrate ADS data and radar data to determine if aircraft separation standards can be reduced. Except for testing use of air-air surveillance to maintain higher arrival rates during reduced visibility conditions in the terminal area, the Safe Flight 21 program will test all of the above concepts in Alaska.

As we evolve toward Free Flight, Safe Flight 21 will help accelerate implementation of NAS technologies and approval of procedures needed to achieve full operational efficiency and safety benefits. This early demonstration and validation of operational enhancements will also serve to reduce the near-term risk of implementing new technologies and the long-term risk and cost of transitioning to the remainder of the NAS. Certification activities associated with Safe Flight 21 will ensure that Free Flight technologies and procedures will meet FAA safety requirements while providing benefit.

6.3 Capstone

The FAA Alaskan Region's Capstone Program of infrastructure modernization provides and validates safety and efficiency improvements recommended in the NTSB Safety Study (NTSB/SS95/05), *Aviation Safety in Alaska.* Capstone focuses on safety by improving infrastructure in Bethel and the surrounding area, a small portion of western Alaska. It will address the operating environment and aviation infrastructure, weather observations and recording, airport condition reporting and adequacy of the current instrument flight rules system. A coalition of Congress, FAA, and the Alaskan Aviation Industry Council supports Capstone as an essential safety enhancement to this aviation-dependent environment. Additionally, these Alaskan modernization efforts will precede and can complement the data collection and risk-reduction efforts of the Safe Flight 21 program. This will occur in three areas: avoidance of controlled flight into terrain, procedural development for enhanced see-and-avoid, and flight information services product development.

6.4 Risk Mitigation

The FAA's Acquisition Management System requires risk management to be conducted throughout all phases of the system life cycle. It is important to monitor risks because mission needs, system requirements, technology opportunities, and program status change frequently. It is especially important to continually monitor risks during NAS modernization because of the interdependencies among programs.

The NAS is an integrated collection of systems that deliver a set of capabilities to NAS users and NAS service providers. A change in one system can adversely affect others. Risk management reduces the number of situations that become problems as well as their consequences. The NAS Architecture is where interdependent program risks can best be identified, analyzed, tracked, and mitigated. Risk management will result in a greater percentage of projects being delivered on time, within cost, and that meet performance expectations.

Risk management is an integral part of program management, which helps implement a system successfully. It can be defined as a five-step process, that focuses on identifying risks, analyzing risks, prioritizing risks, mitigating risks, and tracking and controlling risks. These five steps are discussed in more detail below. The goal of risk management is to invest a small amount of money and time, relative to the total value of the program, to reduce the probability or impact of unplanned events by taking action before a situation becomes a NAS-wide issue. Risk management is preferred because the cost is lower to resolve a problem early, and the time available for developing and considering options is greater, which increases flexibility in dealing with situations.

6.4.1 Risk Management Process

The five steps of risk management are:

- **Identification.** Risks must be identified before they can be managed. One way to ensure more complete risk identification is to categorize the risks. The categories used for NAS modernization are:
  - – *Technical.* Technical risks are present in a program whenever a new technology is being introduced. It is often uncertain if a system can be built with the required performance.
  - – *Operational.* Operational risk is the likelihood that the system that is built will improve the performance of NAS users or service providers.
  - – *Support.* Support risks relate to the ability of the system to be adequately maintained or operated as intended, including the adequacy of training.
  - – *Cost/Benefit.* Cost risk reflects the likelihood that a program will exceed the acquisition program baseline (APB). Cost-benefit risk is the probability that the initiative or activity will not deliver the benefit for which it was developed.
  - – *Deployment.* Deployment risk is the likelihood that, even though a system has been developed successfully, there will be delays in achieving full operating capability because procedures and policies for using the new capabilities are not in place.
- **Analysis.** Risk analysis quantifies the probability of the risk event occurring and the impact (consequences) on the program. The analysis phase includes evaluating program dependencies that contribute to risks by increasing the impact or certainty of a risk event. To understand the total effect of a risk and later define a priority, the risk exposure must be considered. Risk exposure is the combination of the risk probability and the risk impact. As a general rule, the architecture assumes the higher the risk exposure, the higher the priority.
- **Prioritization.** Prioritization helps to apply limited resources to effectively mitigate risk. Risk analysis estimates the risk exposure for various activities. Usually, the highest exposure risks are dealt with first. In addition to the probability and consequences of a risk event, the following factors are taken into account: time criticality of mitigation; time of consequences; the cost of mitigation activities; or the perception of the importance of the risk to the user community.
- **Mitigation.** Risk-mitigation activities on a single program are usually separate, parallel activities that attempt to reduce the likelihood that a risk event will occur, or reduce the consequences of a risk event if it occurs. Risk-mitigation activities include analyses, modeling, prototyping, human-in-the-loop experimentation, parallel alternative development, limited field testing, and other activities designed to increase the success of implementing a capability. Risk mitigation for interdependent activities can be more complex. It is critical for NAS modernization that the combined risks of multiple deployments be assessed as early as possible so that mitigation plans can be implemented.
- **Tracking and Control.** As programs that provide new or improved capabilities for the NAS proceed, their risks change constantly. Every program that is practicing risk management will perform risk tracking and control. Periodically, risks will be evaluated and reprioritized and the risk management strategies adapted accordingly.

6.4.2 Risk Mitigation in Free Flight Phase 1 CCLD

NAS evolution will use a spiral development process. FFP1 CCLD, the first spiral development step, is designed to mitigate risk and evaluate early user benefits at a limited number of sites. FFP1 CCLD capability deployment will occur simultaneously with, and depend on, other modernization activities in NAS Modernization Phase 1. FFP1 CCLD will identify and resolve some of the significant risks associated with the development/deployment of new decision support tools, including procedure development, training, human factors, and user acceptance.

Technical

The future NAS will be composed of multiple new integrated systems. For example, in the en route domain, Traffic Management Advisor

(TMA), CP, data link applications processor (DLAP), weather and radar processor (WARP), and Host/oceanic computer system replacement (HOCSR) will be connected to the NAS local area network (LAN). Consequently, there is a risk that one system could adversely affect the operation of other systems connected to the NAS LAN. FFP1 CCLD will help mitigate these risks through system engineering analysis, deployment, and evaluation at multiple select sites. Information security presents risks. Since many of the new systems employ open architectures and modem networking techniques to distribute and collect information, these systems are vulnerable. These vulnerabilities must be resolved in the early development stage so that risk and cost are minimized.

Operational

The concept of operations cannot be met without new procedures and policies. Information provided by new capabilities will introduce coordination risks that will require changes in NAS participants' roles and responsibilities. Substituting data link messages for voice messages from controller to pilots will require new pilot-to-controller acknowledgment procedures. The objective of CPDLC Build 1 is to test initial procedures and then refine and validate these procedures prior to national deployment.

New capabilities must be operationally acceptable in order for service providers and aircraft operators to use them. Even though the capabilities will have been demonstrated and simulated, there is still a risk that they may not be operationally acceptable. FFP1 CCLD will mitigate this risk through limited deployment and working out the human factor issues. This will help determine performance tradeoffs for operational acceptability and identify unknown human factor issues. Although the new capabilities that make up FFP1 CCLD are designed to produce benefits independent of deployment site, sites differ in many respects. There is a risk that specific capabilities may not be operationally suitable at other sites. FFP1 CCLD addresses this risk by deploying some capabilities to sites with different characteristics. Evaluating the operational suitability at various sites will help define the criteria for national deployment.

Cost/Benefits

Early user benefits will help determine whether to deploy the new capabilities beyond the limited number of FFP1 CCLD sites. The benefits must exceed the costs of implementing, deploying, operating, and maintaining the systems that deliver the capabilities.

Deployment

The deployment schedule will address the ability of users and service providers to accept and implement new systems in a timely manner. Concerns include training schedules, system integration into existing infrastructure, and availability of technical staff to perform the installation.

6.4.3 Risk Mitigation in Safe Flight 21

Safe Flight 21 will provide early field experience to determine the operational acceptability and benefits of proposed new CNS technologies and capabilities, thus mitigating national deployment risks. The following describes some of the risks to be mitigated.

Technical

Safe Flight 21 risk-mitigation areas include certification of avionics and ground systems, requirement stabilization, information security, systems integration, and standards.

Operational

Risk will be reduced through development and validation of new controller and pilot procedures. Validation of initial user benefits will be accomplished in an operational environment.

Cost/Benefits

Products used to provide improved capabilities will be assessed for reliability and ease of use. Safe Flight 21 will enable user avionics equipage costs to be accurately determined.

Deployment

Safe Flight 21 will mitigate deployment schedule risks by involving the user community in the development and use of new avionics and related operational capabilities. User recognition of the benefits derived from these new capabilities will encourage avionics equipage and ensure ground systems deployment in a timely manner. The schedule will be harmonized with the rate of avionics equipage. Experience gained through Safe Flight 21 is expected to expedite the certification of new avionics and ground systems.

6.4.4 Risk Mitigation in Capstone

Technical

Capstone risk-mitigation areas include initial certification of avionics and ground systems, requirement stabilization, systems integration, and standards.

Operational

Risk will be reduced through development and validation of new controller and pilot procedures. Validation of initial user benefits will be accomplished in an operational environment.

Cost/Benefits and Deployment

Capstone will provide the initial data collection for making risk-reducing decisions.

6.5 Summary

The Architecture Version 4.0 provides a disciplined, structured, phased approach to changing the NAS. The architecture uses appropriate program management techniques that rely on risk management. As described earlier, FFP1 CCLD, Safe Flight 21, and Capstone will serve to mitigate risks in modernizing the NAS. Using the five-step approach and adopting a spiral evolutionary strategy that includes FFP1 CCLD, Safe Flight 21, and Capstone, the NAS architecture applies sound risk-management principles to meeting the modernization objectives.

7 SAFETY

To maintain the confidence that the aviation community and the flying public have in the NAS, the FAA is addressing system safety issues associated with modernization. Aviation system safety is the top priority of the FAA, and it will continue to be the top priority as the NAS is modernized and as capacity, efficiency, and flexibility increase.

First, system safety will be enhanced through incremental implementation of new systems while legacy systems continue operation. Second, NAS safety will be enhanced as new technology is introduced and system safety principles are applied in their design. Human performance considerations will be incorporated in the advanced automation technology. New and improved technology will provide pilots and controllers with better information for flight planning and operations and increased situational awareness, and enhanced decision support tools will increase efficiency.

Situational awareness is essential to safe flight. Modernization aims to enhance navigation/station-keeping, in-flight collision awareness/avoidance, terrain and obstacle awareness/avoidance, airspace boundary awareness, weather awareness, and onboard surveillance. Other aircraft and flight planning related applications will also be provided. Advancements in technology will support situational awareness without taking pilots out of the loop and without reducing the time for essential functions such as scanning the airspace.

Safety will be built in from the beginning by identifying where modernization initiatives will require major changes in safety risk management procedures and by applying system safety principles to their development. System safety principles use risk management techniques to systematically identify safety-related risks and provide mitigation to ensure that these risks are eliminated or controlled to an acceptable level. The system safety process includes hazard analysis, risk assessment, risk mitigation, and risk management. Objectives of system safety programs are to design a systematic approach to make sure that:

- Safety is designed into the system in a cost-effective manner
- Hazards are identified, tracked, evaluated, and eliminated, or the associated risk is reduced to an acceptable level
- Historical safety data and lessons learned are considered and used
- Minimum risk is sought in accepting and using new technology, materials, designs, or operational techniques
- Actions are taken to eliminate hazards or reduce risks to an acceptable level
- Changes in design, configuration, or requirements are accomplished in a manner that maintains an acceptable risk level
- Significant safety information is documented, stored, and used in applicable designs and specifications.

The order of priority for satisfying system safety requirements and resolving identified hazards will be to:

1) Design for minimum risk
2) Incorporate safety devices
3) Provide warning devices
4) Develop procedures and training.

The high safety levels of our current aviation system stem from effective risk management, which is based on the following complementary factors:

- Redundancy in certified air traffic control equipment
- Recognized air traffic control standards and procedures
- Thorough controller and aircrew training and certification
- Thorough maintenance technician training and certification
- Evolutionary improvements in aircraft design, crew training, operational procedures, and supporting technologies.

These complementary factors are the foundation of safety-related risk management and the public's high confidence in aviation safety.

PART II

It is important to assess any changes in the NAS from a system safety viewpoint—for example, how changes will affect interfaces, interactions, and redundancies that contribute to the aviation system's inherent safety. Before use, each component of the new architecture will be thoroughly tested to ensure that safety is not degraded by new hardware, software, or procedures. This assessment is also required by FAA Order 8040.4.

7.1 NAS Capabilities

NAS modernization will enhance safety through more effective risk management in critical areas of the aviation system. Recently, the FAA's focused safety agenda, "Safer Skies," identified high-priority safety concerns. Additionally, the FAA administrator has established a risk management policy and has implemented safety risk management as a decisionmaking tool within the FAA. Modernization will strengthen safety risk management in several of these high-priority areas by reducing the potential for controlled flight into terrain and runway incursions, improving flow control of approach and landing operations, and providing better weather information. The following paragraphs describe specific architectural changes that can improve NAS safety.

7.1.1 Navigation, Landing, and Lighting

The navigation and landing portion of the NAS architecture provides system safety improvements by:

- Replacing existing ground-based nonprecision approaches (i.e., approaches dependent on horizontal guidance from ground-based navigation aids) with more precise Global Positioning System/Wide Area Augmentation System/Local Area Augmentation System (GPS/WAAS/LAAS) approach capabilities, which provide vertical descent guidance to all GPS approaches
- Combining GPS with cockpit electronic maps of terrain to enhance cockpit situational awareness.

Eventually, a GPS-based approach will be available at almost every location within the NAS, supported by airport development and the formulation of instrument procedures.

A review of National Transportation Safety Board (NTSB) accident statistics for the United States concluded that approaches with vertical descent guidance (precision approaches) are several times less likely to experience an accident than approaches that lack vertical descent guidance (nonprecision approaches). A related study by the Flight Safety Foundation came to the same conclusions for international air operations.[1]

7.1.2 Surveillance

The entire inventory of terminal primary radar systems will become digital as the airport surveillance radar (ASR)-11 is completely fielded, and ASR-7 and ASR-8 equipment is decommissioned. Digital radars, for technological reasons, are more capable of detecting smaller aircraft at low altitudes, particularly in background clutter conditions. ASR-9 and ASR-11 digital radar systems also provide an improved weather detection and display capability. These improved capabilities can improve safety in terminal airspace.

The entire secondary surveillance radar (SSR) inventory will migrate to a selective interrogation capability. This capability will be modified to acquire position and velocity data from aircraft equipped with automatic dependent surveillance broadcast (ADS-B) via ground-initiated communications broadcast (GICB).

GPS information will improve target-tracking accuracy and enhance the functionality of various air traffic control decision support system (DSS) tools, such as conflict alert, conflict probe, trial planning, descent advisor (DA), Final Approach Spacing Tool (FAST), etc. Improved surveillance accuracy and tracking, linked with DSSs, will significantly aid controllers in separating aircraft from other aircraft, obstacles, and special use airspace (SUA).

Cockpit display of traffic information (CDTI), incorporating ADS-B information, will display nearby traffic, further enhancing cockpit situational awareness and safety.

1. Based on a review by FAA's National Aviation Safety Data Analysis Center of the National Transportation Safety Board accident statistics covering 1983 through 1996 and a 1996 Flight Safety Foundation report covering worldwide commercial jet transport accidents, 1958–1995.

7.1.3 Communications

New digital communications systems, including data link, are expected to decrease verbal air traffic control (ATC) miscommunication of information such as headings, altitudes, or runway clearances. Flight information service (FIS) data link will provide other flight safety information such as current and forecast weather information, notification of navigational equipment status, airfield status, etc. Controller-to-pilot data communications allow controllers to communicate more effectively with aircraft in a congested voice radio environment.

Traffic information service (TIS) will support cockpit displays of other nearby aircraft and call attention to those that are on a converging or intersecting path. For time-critical applications, continuous and automatic information updates will be possible via data link services.

Safety can be improved in many areas by enhanced communications. For example, information about aircraft position is essential to situational awareness and collision avoidance. Aircraft flight object information and enhanced surveillance information will be necessary for flights in areas that do not have radar coverage.

Weather advisory information disseminated through automatic terminal information service (ATIS) and data link can give pilots more timely warnings of hazardous weather and other airport conditions. The next-generation air-ground communications system (NEXCOM) will improve voice communications and data link services, providing both on the same digital radios. NEXCOM will increase the number of usable radio frequencies, enabling better air traffic management.

7.1.4 Avionics

Increased navigational accuracy of GPS-based avionics and nearly universal availability of GPS signals are important improvements over today's navigation aids. GPS, WAAS, and LAAS avionics will provide approach course and vertical descent guidance to pilots for instrument approaches.

WAAS-augmented GPS will provide a navigational signal in space down to Category I (CAT I) minimums at suitably equipped airports. This capability alone is an important improvement over all previous nonprecision instrument procedures such as very high frequency omnidirectional range (VOR), tactical air navigation (TACAN), automatic direction finder (ADF), nondirectional beacon (NDB), and localizer (LOC). These nonprecision approach methods currently depend upon the pilot to establish a suitable rate of descent to arrive at the minimum descent altitude at or before the missed-approach point.

As a practical matter—and putting aside the traditional association of precision approaches with decision heights of 200 feet or less—all GPS procedures will be capable of being used to fly precision approaches (i.e., with both course and vertical guidance). Precision approaches are an improvement over nonprecision approaches in maintaining obstacle/terrain clearance. This satellite-based navigation capability could decrease risks associated with controlled flight into terrain—one of the most common types of fatal accidents in aviation.

WAAS can also improve the accuracy of ground proximity warning systems and, in conjunction with digital terrain data bases, could further reduce the risk associated with controlled flight into terrain.

GPS (augmented by WAAS to meet system safety, availability, and reliability requirements) is expected to be the basis for improved situational awareness through the use of ADS-B and CDTI. Satellite systems also improve navigation on the airport surface during reduced visibility conditions via a moving map display that helps flight crews maintain orientation, even with reduced visual references.

Data link services can aid pilots and controllers by providing quicker and more accurate data exchange. Weather data exchange will give pilots a greater understanding of the winds and weather in a planned flight path. Digital radios will enable clearer voice communication between pilots and controllers and are less susceptible to interference.

Modernization attempts to increase situational awareness and support future operations through human-centered decision support technologies for pilots, controllers, and planners.

7.1.5 Information Services for Collaboration and Information Sharing

Information sharing facilitates controller-pilot collaboration. Local and NAS-level common information services will be used to provide information to pilots and traffic flow planners. Better information can allow selection of the most effective route to destination and alternate airfield and can provide warning of hazardous conditions. Additionally, providing real-time weather information directly to aircrews is essential to identifying hazardous weather conditions. Flight safety can be enhanced by automatic, simultaneous broadcast to the flight deck and service providers of hazardous weather alerts for windshear, microbursts, and gust fronts, as well as icing, turbulence, and thunderstorm information. For the foreseeable future, voice transmission will also continue.

More timely NAS status information, such as runway closings, airport construction, or temporary obstructions, can help aircrews avoid hazards and be better prepared if navigation or airfield facilities become inoperative.

7.1.6 Traffic Flow Management

Traffic flow management (TFM) decision support systems (DSS) work to mitigate demand-capacity imbalances through early prediction and collaborative resolution. These systems will allow better use of system capacity without unsafely overloading either controllers or pilots.

7.1.7 En Route

Automated tools are expected to further improve collision avoidance and reduce operational errors and deviations. New DSSs, such as conflict probe, can monitor aircraft position, predict potential conflicts, and suggest resolutions further in advance than can current alerts. Traffic Management Advisor (TMA) will calculate a more efficient and orderly sequence of arriving aircraft as they approach the terminal area.

Other tools can send ground proximity alerts to help mitigate controlled flight into terrain risk and provide alerts to warn of potential flight into restricted airspace. The planned use of automatic dependent surveillance (ADS) in nonradar areas will extend the benefits associated with radar air traffic services to increasing portions of en route airspace.

7.1.8 Oceanic

The use of satellite communications (SATCOM) and high frequency data link (HFDL) by oceanic service providers and users will provide real-time communications and electronic message routing. This capability will constitute the basis for ADS in oceanic airspace and give controllers more accurate positional data on oceanic flights. This improvement should allow a reduction in separation distances and still maintain or improve safety over the current levels. New oceanic conflict probe and conflict alert decision support tools can be used to help service providers detect and resolve potential conflicts and help prevent controlled aircraft from entering restricted airspace.

7.1.9 Terminal

Controllers will use improved automated conflict detection tools and enhanced ATC displays to separate aircraft from other aircraft (those either on the ground or in the air) and from restricted airspace, terrain, and hazardous weather. Controllers will use integrated weather information, including windshear and microburst alerts, to assist pilots in avoiding hazardous weather and to improve the flow of traffic in terminal airspace. Tools, such as Controller Automation Spacing Aid (CASA) and Converging Runway Display Aid (CRDA), allow controllers to refine the arrival flow of converging aircraft to the primary airport, increasing airport capacity while maintaining safe separation standards. Advanced tactical flow control tools, such as active FAST and DA, promote a steadier flow of aircraft into the terminal airspace.

7.1.10 Tower/Airport Surface

New airport surface detection equipment (ASDE-3) combined with the airport movement area safety system (AMASS) will alert controllers to potential conflicts between arriving aircraft and surface traffic and between aircraft and vehicles at 34 high-use airports. Additional radar and conflict-alerting systems are being planned for other airports. Satellite-based navigation systems, including those augmented by LAAS, improve situational awareness for surface operations. Integrating ADS data with radar data and enhanced ATC displays for airport surface surveillance will further improve surface conflict detection.

7.1.11 Flight Planning

The Operational and Supportability Implementation System (OASIS) at the automated flight service stations (AFSSs) collects information from multiple weather sensors, FAA systems, and other sources. OASIS provides improved weather graphics, route-oriented briefings, notices to airmen (NOTAMs), and SUA notifications and warnings. This information is essential for flight planning and can be very important during a flight. Data link improves in-flight access to flight service station (FSS) specialists.

7.1.12 Weather

Improvements in detecting and forecasting weather can help aircraft avoid hazardous weather situations. The airport surveillance radar-weather system processor (ASR-WSP) expands NAS windshear detection and alert capability. The integrated terminal weather system (ITWS) integrates data from multiple sensors and sources to produce windshear, microburst, and gust front alphanumeric and graphic forecast products to provide improved automated weather information and predictions. Broadcasting ITWS information via the terminal weather information for pilots (TWIP) system to aircraft in or approaching terminal airspace also gives pilots a better opportunity to avoid thunderstorms, hail, icing, and turbulence. ITWS supports proactive rerouting to avoid windshear or severe weather.

In a similar manner, the weather and radar processor (WARP) will provide improved weather data for en route service providers. In particular, WARP provides the weather data from the Doppler next-generation weather radar (NEXRAD) to en route controller displays.

Weather information will be made available, via tailored broadcast or upon request, from a common network available to all NAS users. The FAA will make NAS status and existing weather data available to private data link service providers for the development of FIS products. Commercial providers may make basic FIS products available, at no cost to the government or the user, and may make value-added products available for a fee.

Current and predicted hazardous weather data will be integrated and presented on controller displays. Weather data down-linked from aircraft reporting in-flight conditions will improve weather forecasts. Integrated weather products will be uplinked to the cockpit, initially by FIS to assist pilots in avoiding hazardous weather. An improved and shared view of weather information among aircrews, controllers, dispatchers, and meteorologists enhances weather communications by increasing understanding of weather and permitting collaborative replanning of flights.

7.1.13 NAS Infrastructure Management System

The NAS maintenance workforce will have critical NAS component status information available for remote diagnosis of system problems. A fully fielded maintenance management system will allow technicians to provide more timely and effective maintenance of the NAS infrastructure. Greater availability, quicker restoration, and improved reliability of NAS infrastructure components will enhance the NAS.

7.2 Safety Metrics

Several data sources are available to assess NAS safety. The NAS safety metrics provide baseline information for the NAS as it is modernized. Tables 7-1 and 7-2 show safety trends for the years between 1990 and 1997 for a variety of safety indicators and some of the metrics presently used.

Safety measurement can be based on the record of lessons learned from accidents and incidents. Over the past 30 years, accident rates have decreased for large air carriers and commuter operations.[2] This is the result of both technological and operational changes within the NAS. The accident rate, however, is an after-the-fact measure, which uses past data as a yardstick, which can be

2. Based on National Transportation Safety Board accident statistics for U.S. commercial air carrier accidents, received from the NTSB Public Inquiries Section. This also applies to the worldwide commercial jet fleet, based on statistics released by the Airplane Safety Engineering Division of the Boeing Commercial Airplane Group.

Table 7-1. Accident Trends

Safety Indicator	Description of Aviation Accident Rates	Trend (1990–1997)
Large Air Carrier Accident Rates	This indicator compares the number of accidents involving all large air carriers (i.e., operating under Federal Aviation Regulation (FAR) Parts 121 or 127) to the number of flight hours and departures for these carriers.	Steady for 1990 through 1994 at a low rate; an increase for 1995 through 1997.
Commuter Air Carrier Accident Rates	Compares the number of accidents involving all commuter air carriers (i.e., scheduled carriers operating under FAR Part 135) to the number of flight hours and departures for these carriers.	Up from 1990 to 1991; steady from 1991 through 1992; improving from 1992 through 1994 at a low rate; an increase from 1995 through 1997.
Air Taxi Accident Rates	Compares the number of accidents involving all air taxis (i.e., nonscheduled air carrier operations under FAR Part 135) to the number of air taxi flight hours.	Steady.
General Aviation Accident Rates	Compares the number of accidents involving all general aviation aircraft to the number of general aviation flight hours.	Steady.
Mid-Air Collision Accident Rate	Compares the number of mid-air collision accidents involving all operator types to the number of flight hours for all operators (i.e., large air carrier flight hours + commuter flight hours + air taxi flight hours + general aviation flight hours).	About the same rate from 1990 through 1996, with a dip in the middle years; improvement in 1997.

Table 7-2. Incident Trends

Safety Indicator	Description of Aviation Incident Rates	Trend (1990–1997)
Pilot Deviation Rates	Compares the total number of pilot deviations to total system flight hours.	Down from 1990 through 1995; up in 1996 and 1997.
Near Mid-Air Collision Reports (NMACs)	Presents the total number of system reported NMACs.	Downward trend overall; slight rise in 1997.
Air Carrier Near Mid-Air Collision (NMAC) Rates	Compares the number of NMACs involving all air carriers (i.e., those operating under FAR Parts 121, 127, 129, and 135) to the number of air carrier flight hours.	Downward trend overall; slight rise in 1997.
Operational Error Rates	Compares the total number of operational errors to the total number of facility activities.	Steady.
Runway Incursion Rates	Compares the number of runway incursions that occur at airports to the number of operations at the airports.	Down from 1990 through 1993; up from 1994 through 1997.
Vehicle/Pedestrian Deviation Reports (VPDs)	The number of VPDs. A VPD is an entry to or movement on an airport movement area by a vehicle (including aircraft operated by a nonpilot) or pedestrian that has not been authorized by air traffic control.	Downward trend with fluctuations.

used to predict future behavior and assess risks associated with NAS changes.

System safety risk assessment provides a more proactive approach by identifying safety-related risks early and by applying risk elimination and risk control. This enhancement improves safety.

The NAS is monitored from a system safety approach that acquires accident and incident data. Examples of incidents include operational errors, near mid-air collisions, and pilot deviations. Incident data provide information about events that can lead to potential accidents. Additional metrics may be used over time.

7.3 Summary

Safety is improved through more effective mitigation of risks or elimination of underlying hazards. Extremely complex and effective mitigation strategies support the aviation system's inherent high safety level. The development of the aviation system's mitigation strategies has been incremental and evolutionary as improvements have been made in aircraft design, crew training, operational procedures, and supporting technologies. Potential hazards have been eliminated through design, safety devices, or procedures. Redundancy has been successfully used as a mitigation strategy to reduce the probability that failure of a single element will lead to an accident. This safety risk assessment process will continue as the NAS is modernized to ensure that existing risk is minimized and new hazards are not introduced.

NAS modernization has the *potential* to reduce the number of accidents. Accident rates will not decrease unless the capabilities described in the NAS architecture are implemented and a high percentage of aircraft are equipped with new avionics. Implementation, of course, is dependent on funding and the allocation of scarce resources. Acquisition and installation of new avionics is controlled by numerous users. Furthermore, even when implemented, the architecture's capabilities are not omnipresent; some are available only in selected airspace or at larger airports. A study[3] of particular reports of accidents involving turbulence, hazardous weather in the terminal area, airport surface operations, collisions between aircraft, and controlled flight into terrain indicates that accidents attributed to these factors can be reduced by NAS modernization.

3. *NAS Architecture and Safety*, a preliminary analysis performed by the FAA Office of System Development, January 1998, Wash., D.C.

8 HUMAN FACTORS

The human component of the NAS is a key element of NAS modernization. Focusing on human factors elements of new systems early in the acquisition process reduces costs, minimizes program schedule disruptions, and brings new benefits to NAS users earlier.

8.1 Human Factors Activities—NAS-Wide

A broad range of activities regarding the implications of human factors will be conducted to support NAS modernization. These activities involve both acquiring and applying the information necessary to capitalize on human capabilities and limitations that affect human-system performance in each domain. Human factors engineering research and application activities will be employed to identify and resolve risks and to assess costs, benefits, performance levels, and tradeoffs. Issues for which human factors research and application activities will be employed include:

- Computer-human interface (CHI)
- Controls, displays, and alerts
- Procedures, incremental changes to systems, and system component integration
- Workforce productivity, workload, usability, and task performance
- Training for new automation operation and maintenance; equipment, workspace, and workplace design
- Manpower resources and staffing; unique skills, abilities, characteristics, and tools; communications and teamwork; job and organizational design
- Human performance aspects of safety, health, and environmental considerations.

Through these activities, human factors will be systematically integrated into every phase of NAS modernization. While the range of endeavors undertaken to integrate human factors in the NAS is necessarily broad, six major activities are listed and described below:

- Life-Cycle Costs, Benefits, and Tradeoffs
- Human Performance Metrics and Baselines
- Consistent Computer-Human Interface Prototypes
- Human-in-the-Loop Simulations
- Task Analysis and Workload Measurement
- Workstation Integration.

In addition to its own efforts, the FAA will work with the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), and others to take advantage of their human factors research.

8.2 Life-Cycle Costs, Benefits, and Tradeoffs

Research (and the application of the results) is needed for more information on the costs, benefits, performance levels, and tradeoffs of alternative approaches to meeting NAS requirements. This activity will develop and apply sources of data and help integrate a human performance perspective into investment analysis and programmatic decisions. The activity will provide human factors information to conduct the necessary alternatives evaluations, assess current and future affordability, contribute to the tradeoff analyses and investment decisions, and resolve cost-effectiveness issues during solution implementation. Results of this activity include:

- Identification and description of human factors variables that impact costs, benefits, and tradeoffs (e.g., the types of operational benefits related to human performance on new and upgraded systems)
- Methods to predict and assess the relevant human factors variables and risks that significantly impact system performance (e.g., how to identify the risks of operator cognitive workload for critical functions/tasks in en route, terminal, traffic management, and oceanic domains)
- Algorithms to quantify human factors variables and their relationships (e.g., human-system performance cost-benefit estimating relationships for new display concepts)
- Information related to human factors costs, benefits, and tradeoffs (e.g., establishing the means to assess systems using historical and

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evolving records, such as data on task analyses and training for deployed systems)

- Assessments of the tradeoffs associated with human factors, including personnel selection, staffing, training, and human-system performance.

8.3 Human Performance Metrics and Baselines

As new systems are acquired to replace or augment those currently deployed, human performance metrics and baselines will be developed. These metrics will be used to quantify current operational efficiency and effectiveness, facilitate market survey analysis, assess progress during system development and implementation, and support system performance tests and evaluation. Results of this activity include:

- Metrics to assess human and human-system performance (e.g., standardized metrics and measurement techniques for assessing operator/maintainer workload, staffing, and training for vendor solutions during market surveys)
- Methods to benchmark human-system performance, usability, and suitability (e.g., development and application of techniques, tools, and procedures for determining and mitigating potentially high levels of individual and team communication requirements)
- Ways to link varying levels of human performance to operational system capabilities (e.g., the measures of workload related to the maturity of a system's technology and CHI)
- Development of a comprehensive set of scenarios, system configurations, environmental measures, and simulation concepts for conducting baseline and subsequent assessments (e.g., operational scenarios for terminal operations to evaluate procedural changes)
- Baseline assessments and periodic measurements of NAS systems using human-system performance metrics.

8.4 Consistent Computer-Human Interface Prototypes

Studies have shown that the final cost of software and hardware depends largely on changes to the initial system design. Also, a disproportionate share of system changes are a result of human-system integration and CHI requirements. Without well-planned human-system integration, acquired NAS systems that employ commercially available solutions could result in increased software cost, higher training time, and greater operational complexity. Safety and productivity in the NAS will be enhanced through the development of common interfaces, consistent CHI, and compatible functions and procedures. Results of this activity include:

- Concepts and prototypes for compatible preplanned product improvements (e.g., compatible CHI for terminal and en route upgrades)
- Common CHI designs for systems migrating to common platforms and consoles (e.g., common function and form interfaces for systems transitioning into the NAS)
- Tools, techniques, and capabilities to rapidly prototype new CHI designs, assess vendor CHI solutions, and evaluate the impact of CHI alternatives (e.g., assess the strengths and weaknesses of new CHI designs and specifications for NAS applications)
- Technical standards and specifications for future CHI manufacturing designs (e.g., common core functions, display characteristics, and operational procedures for new Global Positioning System (GPS) receivers)
- Configuration management capabilities to compare CHI compatibility between system components and to design new systems' CHI.

8.5 Human-in-the-Loop Simulations

A method for scientifically predicting how a human would react and perform under certain conditions when operating or maintaining a new system is referred to as a "human-in-the-loop" simulation. Human-in-the-loop simulations of developing systems allow human-performance characteristics to be systematically analyzed and evaluated. Task loading and sequencing, information processing, and crew coordination need to be examined to identify and resolve potential risks and opportunities. Examining these areas will also provide an early indication of whether human performance associated with a system will support NAS performance requirements. Primary results of this activity include:

- Mission scenarios (developed for various domains, with sufficient fidelity to ensure objective, quantifiable measures) that will allow examination of controller and pilot performance in a realistic environment
- Simulation results/findings that verify critical tasks, validate task analyses, refine procedure designs, assess training regimen designs, and identify implied operation and maintenance diagnostic and problem-solving activities
- Comprehensive and consistent assessments and measurement of human performance within systems and across the integration of systems.

8.6 Task Analysis and Workload Measurement

Much of the work associated with task analyses and workload measurement is focused on "time required" versus "time available" for operator and maintainer performance. The measures of time and accuracy (e.g., error rate) will be used with other measures to assess and improve human-system performance. These measures will supplement subjective rating scales that provide insights into user attitudes, but do not always correlate with objective measures of performance. Primary results of this activity include:

- Validated tools and techniques, both objective and subjective, to provide measures of the cognitive task and workload assigned to operators and maintainers
- Data bases to support development of task analyses and workload measurements
- Resulting analyses and measurements that describe human-system performance at the required component level of the system.

8.7 Workstation Integration

Human factors activities related to workstation planning, analysis, and implementation will ensure that the design of the workstation is suitable for its intended application and use by the system operator and maintainer. Primary results of this activity include:

- Methods to describe and control the design of complex workstation configurations
- Design guidelines for systematic integration of a variety of control and display devices to enhance operator and maintainer performance
- Design and implementation analyses, alternatives, and recommendations for configuring future workstations and NAS workstation environments.

8.8 Summary

These human factors activities provide a framework for developing and implementing human-system performance advances in the NAS. It is important to recognize that the description of these activities represents only an outline of the necessary steps toward achieving the NAS human factors objectives. While the description of the human factors work in support of NAS development may be categorized into broad, generic areas and activities, the work that is performed must be tailored to the specific systems and issues to be addressed in each domain. Detailed human factors research and application efforts within each domain are required to institutionalize the consideration and resolution of human performance issues and reduce many of the operationally significant human performance challenges facing the nation's aviation system. An overview of the work to be accomplished in each domain is discussed in the domain writeup.

9 INFORMATION SECURITY

The current NAS is a collection of systems, each evolving independently over time to support a major NAS functional area. As modernization proceeds, these independent systems will migrate toward an open architecture with more interaction between systems both inside and outside the NAS. While numerous benefits can be gained from open systems and standard data formats, the risk of unwanted disruptions of critical NAS services also increases. To decrease this risk, the architecture identifies key risk areas and proposes mitigating strategies.

Information security (INFOSEC) is integral to the NAS architecture. While not an obvious contributor to NAS functionality, INFOSEC is essential to ensuring the availability, integrity, and confidentiality of NAS operations. To protect NAS systems, INFOSEC must be engineered so that NAS functional performance and cost tradeoffs include appropriate protection whenever sensitive systems are involved. This includes, for example, all processing, storage, and communication of air traffic control (ATC) information. This section provides a high-level INFOSEC approach, but does not discuss detailed protective measures.

9.1 Need for Information Security

Safeguarding information systems used for NAS operations is an essential part of the NAS architecture. In addition to data directly related to ATC operations, sensitive or proprietary information pertaining to NAS users must be protected.

An effective NAS INFOSEC architecture encompasses many activities, ranging from policy to testing. These activities must be covered over the life cycle of NAS systems. The INFOSEC aspects of the architecture must define investment strategies that balance threat and potential vulnerabilities against investment costs.

9.2 Evolution of Information Security

The NAS is evolving to embrace new systems and open systems. This evolution has resulted in an increased use of common industrial standards and commercial off-the-shelf (COTS) products and a decreased use of proprietary systems. These changes emphasize the need to manage security interfaces among systems and to fully utilize the security features of COTS products to protect the NAS.

9.3 Scope of NAS Information Security

An information security architecture ensures the use of appropriate and uniform security measures across NAS subsystems, elements, and services. The architecture addresses NAS operational systems, as well as any administrative systems connected to operational systems. Interfaces between these and other systems (e.g., user systems or other government systems) are also addressed. Public networks, which are used to transfer information between facilities and systems within the NAS, are considered vital avenues of access into the NAS. The FAA will focus on ensuring information security at the interface points between the NAS and public networks.

Since the NAS is a "system of systems," security between different systems—as well as security within individual systems—must be emphasized. Processing, storing, and transferring information within and across systems must be secure. This prevents attacks that use one weak system as an entry point from which to probe and penetrate other NAS systems. As shown in Figure 9-1, the goal of INFOSEC is to protect the availability, integrity, confidentiality, and authenticity of data used in NAS operations.

9.4 Information Security Approach

Analyses of NAS systems, along with assessments of security products and services, are used to develop security profiles. System acquisition personnel use these profiles to match characteristics of particular systems with appropriate security products and services. Coupled with appropriate policies and procedures, profiles provide an integrated approach to information security in the NAS.

A management structure will administer security processes from an operational viewpoint and participate during the acquisition phase of the life cycle. A systemwide concept of operations (CONOPS) for information security ensures uniform security measures within individual systems and compatibility across systems.

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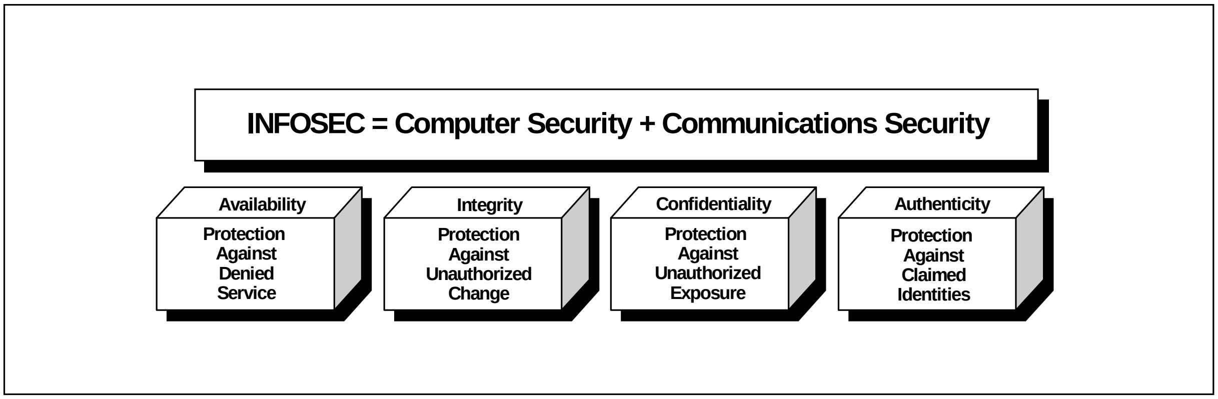

Figure 9-1. Goal of Information Security

9.5 Information Security Elements

INFOSEC policy, CONOPS, and security engineering process drive the security approach. Figure 9-2 illustrates the relationships among these elements. As a component of the NAS architecture, the security architecture provides high-level technical guidance on security-relevant structural aspects of NAS systems.

INFOSEC policy establishes basic ground rules to guide the CONOPS and Security Engineering Process, and thus guide the security approach.

The INFOSEC CONOPS is aligned with future directions for air traffic control operations, as well as with the technical and organizational changes associated with a centralized approach to NAS infrastructure management. The INFOSEC CONOPS defines functions to support the following objectives:

- Enforce INFOSEC policy
- Maintain preparedness for prompt response to rapidly changing risks and security technologies.

The INFOSEC engineering process defines acquisition-relevant INFOSEC functions that are consistent with:

- Progressive realization of NAS security protection through sound security practices

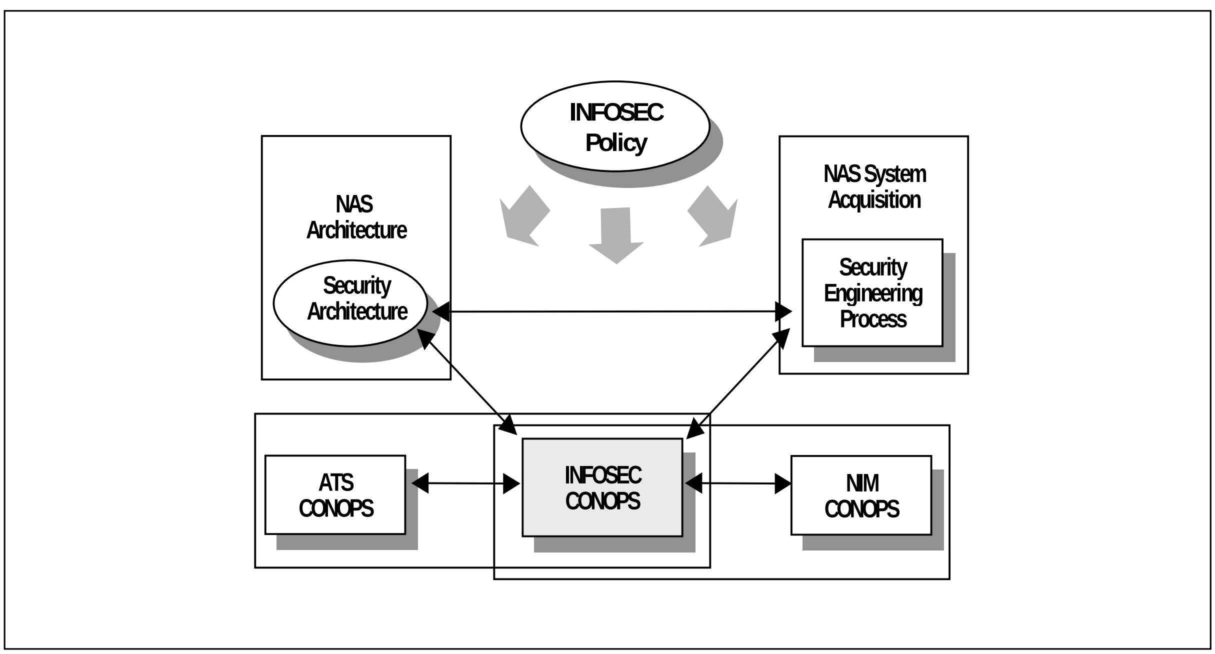

Figure 9-2. Relationships Between Major INFOSEC Elements

- Revised FAA acquisition procedures
- Fielding systems for operational use without introducing new vulnerabilities.

9.6 Technical Capabilities

As a part of the NAS architecture, INFOSEC capabilities will support multiple logical barriers to provide a layered defense of NAS systems. One barrier consists of countermeasures integrated into individual systems to protect local operation.

Another barrier is created by adding countermeasures at the entry points where external systems connect to the NAS. Countermeasures include firewalls, proxy servers, and security gateways to control communications access in a distributed network. This barrier secures NAS operations against unauthorized access from external systems. A further barrier consists of countermeasures to authenticate users within communities-of-interest, such as air traffic control, air traffic management, and flight services. Common security services support the various barriers. For example, one service involves audit collection and system monitoring, and another service provides tools for security administration.

9.7 NAS Functional Areas

9.7.1 Communications

Air-air, air-ground, and ground-ground communications have specific characteristics that must be evaluated separately to determine their contribution to vulnerability and risk to the systems within the domains over their life cycles. The FAA information security engineering process will be applied in determining communications vulnerabilities and the required countermeasures needed to control communications-related risks. Future security services will preserve the availability, integrity, confidentiality, and authenticity of NAS communications.

9.7.2 Navigation, Landing, and Lighting Systems

With precision landing services eventually depending primarily on the use of Global Positioning System (GPS) signals augmented by Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) differential correction signals, there is a need to protect these systems from harmful interference. The FAA is currently working to develop safety and system security countermeasures for satellite-based navigation and landing systems to prevent or mitigate interference. The backup navigation and landing system capabilities that are needed to protect against intentional jamming and signal interference will be defined.

The FAA and the users, through RTCA, Inc., are currently reviewing the backup requirements for GPS. The likelihood of interference is the primary threat to GPS navigation. Any backup determined as being necessary must support at least nonprecision approach capabilities, for it is in the landing phase that interference will be most disruptive.

9.7.3 Surveillance

The evolution of the surveillance system architecture introduces new information security risks for automatic dependent surveillance broadcast (ADS-B) surveillance reports. Potential surveillance security concerns include interference with WAAS correction signals, which affects the accuracy of ADS-B data; interference with GPS signals, which denies ADS-B service in the affected area; and message flooding of the surveillance system.

Security features are needed for the surveillance systems to ensure continued operations during these types of events, which is one of the reasons for continuing secondary surveillance radar (SSR). Provisions will also be considered for detecting unusually high message activity on surveillance inputs and generating a warning. Sharing surveillance information will necessitate special security provisions, including access control, user verification functions, and restrictions on the types of information that each user group can access.

9.7.4 Avionics

Avionics is the primary airborne component of the communications, navigation, and surveillance systems. The security considerations that apply to the avionics interface with these systems are summarized below. Using the NAS information security engineering process, the integrated product team (IPT) will work with the NAS Information Security Program during the entire life cycle of a fielded system, especially during functional upgrades and technology refresh, to identify the need for protection mechanisms.

- *Communications.* The next-generation air-ground communications system (NEXCOM) radio will be used to exchange real-time, safety-critical flight clearance information with the cockpit. The NAS information security engineering process will identify security provisions and countermeasures to be incorporated in the NEXCOM system design.
- *Navigation.* GPS, WAAS, and LAAS will be used as the primary means (systems) of navigation. Intentional and unintentional interference with GPS signals may result in a hazard that affects many aircraft simultaneously. This potential problem will be fully evaluated within the overall GPS, WAAS, and LAAS operational evaluation programs.
- *Surveillance.* The NAS architecture includes an automatic dependent surveillance (ADS) position reporting capability. Security provisions will be developed against possible interference and erroneous data transmission.

9.7.5 NAS Information Services for Collaboration and Information Sharing

Security will become a more complicated issue as the NAS-wide information network evolves. The sources and users of electronic data will increase substantially, as will the quantity and types of data available. Protecting the integrity and privacy of information will be critical to NAS-wide information network effectiveness (i.e., users must have confidence in data they access and that proprietary data are protected). New security systems and procedures will be implemented. Authorized users will have access to information—whenever and however they require—and unauthorized individuals will be denied access.

9.7.6 Traffic Flow Management

The traffic flow management (TFM) system allows users to obtain NAS information, electronically transfer flight plan data, and develop flight plans collaboratively. The TFM system receives, stores, and disseminates sensitive data from airline operations centers (AOCs), which will require solid information security measures. These security measures include logical separation of administrative and operational data, protection of sensitive AOC scheduling data, Internet access controls, firewalls, role-based access controls, and security gateways between the TFM network and any connected, nonsecured systems.

9.7.7 En Route

En route automation will be extended to support collaborative processing, flexible airspace structures, dynamic routes, and self-separation. En route technology will transition from relatively closed systems to open systems. Communications among systems will increase significantly, and data messages will replace many existing air-ground voice communications. New types of data structures will be implemented, and new classes of users will need to work with en route data.

Throughout en route modernization, service providers and users will need to identify appropriate security services. These services include authentication to protect the system from unauthorized access, integrity to protect messages containing sensitive information from corruption, and encryption to protect the privacy of data or to enhance authentication. Additionally, security training and administration will be the primary protection mechanisms during the operations and maintenance phase of the life cycle.

9.7.8 Oceanic and Offshore

Two classes of security are relevant to the oceanic system. The first is protection of the air-ground and ground-ground communications links. The second is protection of the ground-based components of the oceanic systems, which include automation and communications subsystems. The key services are user identification and authentication, access control, and an interface protection mechanism.

9.7.9 Terminal

The terminal domain contains several sensitive decision support systems that require security services. These services include authentication to protect the system from unauthorized access, integrity to protect messages containing sensitive information from corruption, and encryption to protect the privacy of data or to enhance authentication. In addition, security training and administration are key protection mechanisms during the operation and maintenance phase.

9.7.10 Tower and Airport Surface

The tower/surface automation and communications subsystems include a surface movement adviser (SMA) system and an air-ground tower data link service (TDLS). These systems must be protected against security breaches. For example, the SMA system will interface with AOC facilities at airports. Hence, there is a need to protect schedule and aircraft movement data on the SMA communications circuits and in the FAA and airline data bases.

Security concerns include unauthorized user access and modification or destruction of sensitive information used for surface operations control. Another concern is the air-ground data link, which will handle safety-critical clearance and real-time messages. Potential security breaches include unauthorized clearance transmissions and modification of messages on ground links. Provisions to mitigate security risks may include installation of security gateways between the FAA operational system and outside users and between the NAS information system and the TDLS access controls; message origin and message traffic verification; and security protection of surface control and movement data bases.

9.7.11 Flight Services

Flight services interacts with pilots and agencies outside the FAA. To meet its objectives, flight services must also interface with other NAS systems, including the weather and radar processor (WARP), the weather message switching center replacement (WMSCR), the en route automation system, and traffic flow management systems. Thus, the flight service system (i.e., the Operational and Supportability Implementation System (OASIS)) needs security services that include access control, user identification, and security gateways to protect availability, integrity, and confidentiality for itself and other interconnected systems.

9.7.12 Aviation Weather

Weather products are received both from FAA sensors, the National Weather Service (NWS), and commercial vendors. Weather messages flow among the FAA sensors, the integrated terminal weather system (ITWS), WARP, operational ATC systems, and the user community. Weather systems require protection against injection of false weather messages, unauthorized access, and unauthorized modifications of weather data bases. Security provisions for the weather subsystem will include access control, message sender authentication, and audit functions to record all messages and to identify the source of each message.

9.7.13 Infrastructure Management

NAS Infrastructure Management (NIM) tools interface with all other NAS systems, and its security access must be protected. For this reason, the management and control of NAS security services is a logical candidate for future inclusion in the NIM architecture. NIM tools could be used to collect NAS-wide subsystem security data for reporting and auditing purposes and to perform NAS-wide intrusion detection.

Within NIM tools, INFOSEC requirements are based on the NIM protection profile and vulnerability assessment. Meeting requirements for service availability, access control, authentication, nonrepudiation, and confidentiality will ensure adequate security for NIM tools. In particular, appropriate security gateway services are available to provide proper access control between NIM tools and other NAS systems.

Security management will allow the FAA to protect NIM tool data via user identification, authentication, and access control mechanisms. NIM tools could also support NAS-wide security management, such as detecting and logging NAS infrastructure security violations for reporting to FAA management.

9.8 NAS Information Security Cost

The FAA’s estimated costs for NAS information security modernization are depicted in Figure 9-3. These costs include initial estimates for developing INFOSEC requirements and limited IPT support. The NAS INFOSEC process is awaiting investment analysis and Joint Resources Council (JRC) determination.

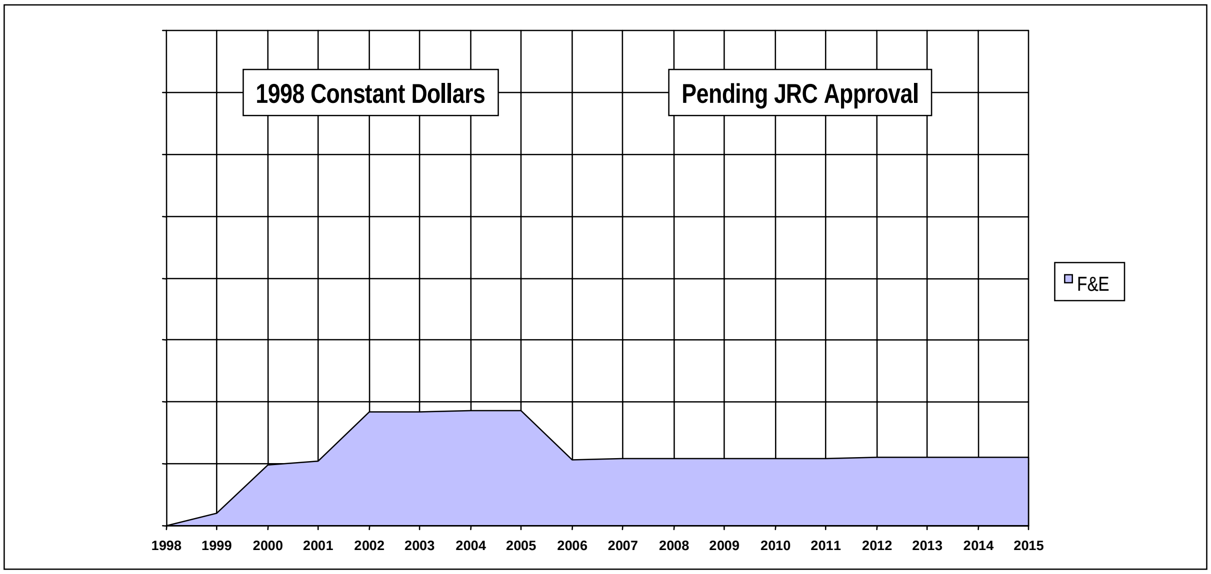

Figure 9-3. Estimated INFOSEC Costs

9.9 Summary

The present NAS is robust and extraordinarily resilient. NAS modernization includes the addition or revitalization of many programs. On the one hand, these programs bring new capabilities that enable future benefits. On the other hand, expanded functionality, greater connectivity, and well-understood commercial technology call for increased INFOSEC vigilance. The future NAS must implement a coherent INFOSEC architecture that mitigates these risks. Protection must extend throughout a system's life cycle. By applying sound INFOSEC principles during planning and design, the future NAS will retain its present resilience while addressing future concerns at acceptable costs.

The *National Airspace Architecture Version 4.0* does not provide specific architecture details for INFOSEC. This information is considered sensitive and would increase NAS vulnerability. The information security architecture is provided on a need-to-know basis.

The next section describes the role that research, engineering, and development plays in the modernization process. Successful research efforts are the key to unlocking the potential of new and, in some cases, yet to be discovered technologies.

10 RESEARCH, ENGINEERING, AND DEVELOPMENT

While numerous technologies employed during the early phases of NAS modernization are mature and well understood, many proposed possible paths for the later stages of modernization are just now emerging. Research, engineering, and development (R,E&D) activities will play a major role in assessing emerging technologies and discovering more advanced technologies that could be employed in modernization. This section describes the research efforts needed to fully understand and exploit the new and emerging technologies described in this architecture.

The FAA R,E&D program develops and validates technology, systems, designs, and procedures, along with supporting the agency's strategic requirements determination process. Today, the NAS is under heavy pressure to keep pace with rising traffic demand, needs for essential safety and security improvements, airspace user requirements for more flexible and efficient air traffic management operations, and demands for further mitigation of the environmental impacts of aircraft operations. As air travel increases, the agency's research and development work will take on added significance.

To meet these future challenges, the FAA employs a comprehensive, agencywide R,E&D investment analysis process to ensure that available resources remain customer-focused in terms of "outcomes" and "outputs," as mandated by the Government Performance and Results Act (GPRA) of 1993, and that these resources are targeted on the highest-priority activities.

The R,E&D program is divided functionally into seven areas. These areas are: Air Traffic Services, Airport Technology, Aircraft Safety, Human Factors and Aviation Medicine, Aviation Security, Environment and Energy, and R,E&D Program Management.

10.1 Air Traffic Services

The Air Traffic Services (ATS) R,E&D program is part of an integrated strategy intended to increase the scope and effectiveness of air traffic services at the most economical cost. ATS research is the agency's preferred means of leveraging its ATS investments for improved services, procedures, and infrastructure. ATS research integrates new concepts and technology, as required to meet demands for improved safety, efficiency, and productivity. The ATS RE&D programs yield operational concepts, human factors and performance guidance through simulation and analysis, standards for application of new technologies, prototype developments and evaluations, and software products for integration into current and future operational systems.

Listed below are the specific ATS research activities required for the modernization efforts detailed for each domain of this architecture (as described in Part III). The activities are identified by the appropriate modernization phases based on the time required to perform the activity and the completion date required to support enhancements to existing operations and deployment of future systems, as detailed in the NAS modernization schedule. As a result, this architecture represents a completely integrated program planning document depicting the most efficient and cost-effective approach to achieving the desired capabilities. If appropriate funding is not approved for R,E&D activity, there likely will be delays in the associated development schedule.

Currently, the FAA is reassessing the R,E&D program due to Congressional funding authorization actions. ATS services research is now funded by the facilities and equipment (F&E) budget. Although this will have some impact on the plan, the overall philosophy of the research activities that will be implemented out of F&E is consistent with the plan laid out here.

10.1.1 Navigation, Landing, and Lighting Systems

Phase 1 navigation and landing R,E&D will evaluate and develop the guidelines and procedures for the Global Navigation Satellite System/flight management system (GNSS/FMS) (or equivalent system) for precision arrival and departure paths. Standards, including minimum operational performance standards (MOPS) and technical standard orders (TSOs), will be developed for the Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) technologies to support their implementation into the NAS and to promote international acceptance.

Research will be conducted on the procedures, specifications, and design for a redundant system.

Other R,E&D activities will include investigating the use of security services to guarantee the availability and integrity of navigation services. As the ground-based very high frequency omnidirectional range (VOR) infrastructure is phased-down, a set of named grid points[1] will be established to replace the VOR and fix locations. R,E&D will look into developing a low-cost runway lighting system to support the expanded capabilities provided by satellite-based navigation.

Phase 2 research will investigate alternative satellite-based configurations for providing navigation services. It will also investigate an inexpensive ground-based navigation system for providing selected backup capabilities.

10.1.2 Surveillance

The goal of surveillance research is to extend surveillance, using satellite-based position reports, to nonradar and surface environments and to provide a more cost-efficient and safe surveillance service for the NAS. Services stemming from this research include extending surveillance to these environments to improve situational awareness of both service providers and flight crews, ensuring that this coverage includes all operating aircraft. The planning within the surveillance architecture indicates that automatic dependent surveillance (ADS) will evolve to be the principal surveillance reference and a key to NAS capacity enhancement.

In addition to demonstrating ADS technology during the Safe Flight 21 program, Phase 1 research will investigate the best means for integrating ADS into the NAS ground-based infrastructure and obtaining the operational benefits associated with ADS. Development of an ADS ground system design—including standards, procedures, and system-level specifications—will then proceed. As a means of improving target position accuracy, research will identify the types of data to be fused and how and when they will be fused—leading to the development of a system specification.

As surveillance systems evolve to provide greater accuracy, research will need to determine the benefits, procedures, and human factors impact of reducing separation standards.

Phase 2 research will define backup strategies—given that surveillance and navigation merge when using the Global Positioning System (GPS) as a source for both. The architecture requires and designates at least two complementary means of surveillance in each domain. This work will study alternative approaches and lead to the validation of a selected solution. Before the end of the useful service life of the airport surface detection equipment (ASDE)-3 surface surveillance radars, a research effort will support development of a low-cost strategy for tracking all vehicles on the active airport surface.

Future research will investigate alternatives for replacing the terminal radar/beacon systems, terminal Doppler weather radar (TDWR), and other terminal surveillance sensors with a single system, upgrades of a present system, or a different type of service.

10.1.3 Communications

The goal of communications research is to improve aviation-related information exchange between service providers and all users of the NAS with greater efficiency and at lower cost. This information exchange will be used to enhance situational awareness for both the flight deck and service providers in all domains. Based on the extensive use of data link envisioned for the future, specifications will be developed for communication links, message protocols, avionics requirements, and certification of service. Associated cost-benefit analyses will be completed. Data links will be developed to integrate the aircraft FMS capabilities with the ground-based decision support automation, which will allow more efficient operation of the aircraft and the air traffic control (ATC)/management system.

Phase 1 efforts will include human factors analysis that addresses the flight deck and ground systems associated with data link and the viability of operational procedure enhancements made possible by data link. Additionally, a communications

1. Named grid points will provide a common reference for fixed ground locations.

strategy with associated cost-benefit analysis will be developed to provide NAS-wide information service data to all interested parties for their use in operating within the NAS. Because the Agency has plans for increased access to more information, Phase 1 research must be conducted to develop information security strategies for interfacility, ground-ground, and air-ground communications. Communications research is also required to develop domestic and international digital signaling standards for current and future ATS voice switches.

In Phase 2, the availability of low earth-orbiting/ medium earth-orbiting (LEO/MEO) satellite networks will allow satellites to be used for new applications, with the cost of these services expected to decline. Research will investigate a satellite communications strategy for air-ground communications, including FAA-owned and -leased systems and GPS enhancements.

Alternatives and methodologies studies will be conducted for the aeronautical telecommunication network (ATN) to examine the system conditions required for optimal performance of each communications scheme, as well as the degree to which those conditions meet the requirements. The performance and capacity of the designed ATN will then be validated using actual data from an implemented integrated system. This validation will help ensure that, for strategic planning purposes, any ATC service provider can communicate with the flight deck of any aircraft, regardless of the aircraft's location.

Department of Defense (DOD) systems that incorporate the latest, most efficient, and effective technologies offer great potential for economically accommodating a variety of civil as well as military air-air and air-ground communications needs. The systems also demonstrate that continued cooperative FAA and DOD system development and procurement offer a clear way to avoid duplication of effort.

10.1.4 Avionics

To realize the full benefits of modernization, users must equip with new avionics. In Phase 1, research will examine the minimum avionics required—and the cost involved—to obtain various levels of NAS services. The program will develop recommendations for improving the avionics certification and testing process, including reengineering the certification process for efficient, affordable certification. Research efforts will study the development of standards, certification processes, and technology applications intended to lower the cost of avionics and improve safety and efficiency through higher levels of avionics capability and equipage for the general aviation (GA) community.

In conjunction with the Human Factors Research Program, research will investigate the human factors issues associated with using multifunction displays to support situational awareness. A major focus of human factors research will include assessing how to best use the limited panel space available and assess the effects of new avionics on single-pilot operations. Standards and procedures for pilot separation assurance in cases such as station-keeping over ocean and on final approach will be investigated.

A study will also examine the range of services provided to aircrews by automatic dependent surveillance broadcast (ADS-B), as well as related aircrew procedures. Avionics research goals include improving flight deck situational awareness through cockpit display of traffic information (CDTI) and providing timely information about weather, flight plans, predeparture clearances, and taxi path assignments. Flight deck utilization of automatic weather alerts and graphical weather data will be examined.

To support search and rescue efforts, a program will develop emergency locator transmitters (ELTs), which transmit aircraft identification and GPS-based position information.

Research will result in improvement or development of the following avionics services.

Navigation and landing enhancements include:

- Increased use of satellite-based radionavigation routings
- Implementation of additional FMS-guided procedures
- Location with reference to terrain obstacles and special use airspace (SUA)
- Taxi routes and position on the airport surface

- Landing guidance to broad areas (i.e., precision and nonprecision, decelerating, curved, and segmented precision approaches (for fixed wing and helicopters)).

Surveillance and user-supported separation enhancements include:

- Tracking of all vehicles on airport surface (ADS-B, infrared, etc.), based on performance impact assessment for controllers and/or pilots
- Position of all close-by aircraft
- Station-keeping in selected oceanic airspace to reduce separation standards and provide in-trail climb and in-trail descent
- Transfer separation assurance to the cockpit for some simultaneous approach operations
- Taxi routes and position on surface provided to and monitored on the flight deck
- Station-keeping on final approach.

Communications enhancements include:

- Data link capabilities on airport surface
- Predeparture clearances by data link
- Altitude, heading, and speed assignments; frequency and transponder code changes; and certain clearances provided by data link to aircraft
- Rerouting and clearance amendments
- Planning tools and digital negotiation capability for tactical and strategic replanning
- Access to weather data and ability to update flight preference in the flight object
- Performance and intent data automatically from onboard systems (i.e., FMS).

Weather enhancements include:

- Graphical weather display available to the cockpit
- Improved weather information from a common weather data base shared between NAS service providers and users
- Fully automated terminal information service (ATIS) and terminal weather advisories delivered by voice and data link
- Aircraft downlink of winds aloft, humidity, temperature, and turbulence.

Additionally, new areas of research will be investigated as experience is gained with new cockpit avionics and procedures.

10.1.5 Information Services for Collaboration and Information Sharing

Phase 1 research will support evaluation of information requirements for the operational concept and implementation of the NAS-wide information service and the flight object. Standards and procedures will be developed to support implementation of information services that will enable greater information sharing between NAS users, leading to increased collaboration and improved decisionmaking.

Phase 2 research will focus on information distribution and access, including large storage technologies, data warehouse technologies for real-time decision support combined with intelligent distribution, and search and access technologies in the object-oriented world. Research into seamless interoperability with data integrity built in is essential for one NAS-wide coherent homogeneous system of systems.

10.1.6 Traffic Flow Management

In Phase 1, research will focus on developing expanded methods for cooperatively managing demand capacity imbalances with the users.

In Phase 2, tools to support the real-time management of alternative airspace designs will be investigated. Additionally, the goal in Phase 2 is to develop information and tools that can be used at all levels of the traffic management system so that capacity constrictions can be identified and solved at the most appropriate level.

The Phase 3 research goal is to provide decision support system (DSS) tools to service providers, flight crews, and airline operations centers (AOCs) for strategic air-ground traffic flow management (TFM) collaborative decisionmaking (CDM) and problem resolution. Some tools could include 4-dimensional flow analysis and flight object identification. These tools will help ensure that any imposed flow restrictions are necessary and executed effectively. Improved methods for identifying and predicting dynamic density problems will be designed. Postflight analysis must provide users and service providers with information about NAS performance strategies to optimize future performance.

10.1.7 En Route

The goals of en route research are implementation of separation standards matched to the accuracy of the positional information available, to relieve frequency congestion, and provide conformance monitoring of the flight profile. Achieving these goals will allow a shift in controller workload and assist controllers in separating aircraft from weather, which will increase throughput in en route airspace. Throughput may also be increased by transferring separation assurance to the flight deck in certain situations and allowing more user-preferred trajectories to be flown. The research efforts that support the en route domain will focus on greater utilization of the aircraft flight data management system, continued access to expanded flight information, improved decision support tools, and enhancements of data link applications to send and receive data in a more intelligible form.

Phase 1 research will evaluate airspace design alternatives for reduced vertical separation while accounting for the need to accommodate non-equipped aircraft in the airspace. Decision support tools for 4-dimensional flight profiles, hazardous weather, and ADS intent data as well as improved trajectory design tools will be developed to enhance aircraft monitoring and conflict prediction. Research will investigate methods of more precise separation and flight progress monitoring and of dynamic route structuring adapted to flight-level winds, hazardous weather, airspace demand, and user preferences.

In Phase 2, research will be conducted to validate the concept of dynamic sectorization of airspace to best match controller and traffic workloads. With the move to data link, design concepts will be investigated to determine how altitude assignments, frequency changes, and limited numbers of clearances can best be provided. Supporting en route controllers with an enhanced conflict detection capability, decision support software will be designed to monitor an aircraft's conformance to its intended profile. Research efforts will also look at more effective means of displaying flight progress information and concepts for other backup modes of operation.

In Phase 3, research will evaluate the flight object to determine how its detailed flight plan and trajectory information can be utilized to provide additional benefits to users and service providers. An effort will be made to determine how to probe all flight profiles when major environmental changes occur and how to provide access to this information for the flight deck, AOCs, and service providers to facilitate the strategic replanning process. Tools that will recommend flight profile changes based on present and predicted environmental changes will be investigated. Additionally, research will look at how to evolve the oceanic, en route, and terminal domains into a consistent, seamless operational environment that provides more precise monitoring of separations and flight progress.

10.1.8 Oceanic

A primary goal of oceanic research is to investigate procedures and separation standards that are related to the ADS capability to provide position and intent information to controllers and users. Other R,E&D goals are to develop a reliable digital air-ground communications system, to investigate flight deck/controller workload issues, and to monitor aircraft conformance to planned route of flight. In Phase 2 and Phase 3, the oceanic and en route domains will evolve toward a consistent, seamless operational environment.

10.1.9 Terminal

The research goals are to provide DSS and automation tools that help controllers establish optimal runway assignments and efficient arrival and departure paths. The tools will also support digital communications to the flight deck, implementation of reduced separation standards (commensurate with improved surveillance), and flight plan conformance monitoring. Automation tools will be integrated across facilities for consistency in optimizing traffic flow. Collectively, these tools will enable the number of departure and arrival paths to be increased and allow for more efficient arrival trajectories, including providing wake vortex spacing.

Tools will be developed to support data link transmission of altitude assignments, frequency changes, and certain clearances to aircraft. Research efforts will also investigate automated methods for controllers to coordinate gate and runway assignments with arriving aircraft in near real time.

Phase 1 research efforts will evaluate a streamlined method for designing and certifying arrival and departure routes. During Phase 2, research on integrating the automation decision support system to meet terminal and offshore requirements will determine the appropriate level and extent of integration. Information display techniques will then be developed to integrate surface, terminal, and wake vortex information into a simplified format to support departing and arriving traffic sequencing. Data link applications that support air-ground negotiation of arrival trajectories will be investigated. Phase 3 research on the integration of the automation decision support system to meet terminal and surface requirements will determine the appropriate level and extent of integration. Research efforts will also examine more effective means of displaying flight progress information and concepts for other backup modes of operation.

10.1.10 Tower

Tower-oriented research will provide decision support system tools and associated systems integrated with terminal automation tools. This research will support predeparture clearances by data link; real-time collaboration with terminal; dynamic planning of surface movement; better coordination of local operations based on arrival information and surface and departure schedules; surface and airborne surveillance information; and flight and weather information. This information will be provided to service providers, airline ramp operators, airport operators, and airport emergency center personnel.

10.1.11 Flight Services

The research goal in this domain is to develop decision support tools and associated systems for interactive preflight planning. The system will provide planners with information (such as NAS constraints, SUA status, and notices to airmen (NOTAMs)) and feedback about nonapproved segments of the proposed flight plan. The system will also propose alternatives so that a planner is able to select the optimum route. Capabilities improved by this research include interactive flight planning and reduction or restructuring of visual flight rules (VFR) flight plans (using the NAS-wide information service and the flight object).

The research will also investigate improvements to search and rescue capabilities using aircraft-transmitted ADS-B position and identification. Additionally, this capability will also incorporate data received from the newly developed ELT, which provides discrete identification codes and GPS-based position information (see Section 18, Avionics).

Phase 2 research efforts will enhance interactive flight planning and alternative route development decision support tools. It will also enhance search and rescue operation efficiency. Research will look at the design of compatible domestic and international flight plan/flight object formats to allow for increased preflight and in-flight information exchange among service providers and users.

Phase 3 research will develop the guidelines and specification for the detailed time-based trajectory flight profile that will replace the flight plan.

10.1.12 Aviation Weather

The aviation weather research program focuses on applied research and conducting limited basic research through collaboration with other federal and academic institutions. The program aims to generate more accurate and accessible weather observations, warnings, and forecasts that allow the FAA to solve operational problems. Research focuses on these areas:

In-Flight Icing. The goal is an hourly, gridded depiction or forecast of in-flight icing. Research on freezing drizzle and icing severity will continue.

Aviation Gridded Forecast System. This system mitigates communications bandwidth problems by transmitting the weather data as gridded data fields, which are smaller than large graphic files. Mesoscale models will use higher resolution grids and improved algorithms to provide refined, critical weather elements data—such as convection, icing, and turbulence—to the aircraft.

Weather Support to Deicing Decisionmaking (WSDDM). To optimize ground deicing operations, WSDDM software will produce an accurate graphical depiction of the real-time, 30-minute nowcast and a 4-hour forecast of precipitation intensity and type, weather condition, temperature, and wind speed for the 10-kilometer area around an airport.

Humidity and Turbulence. Sensors are installed on board commercial aircraft to obtain outside humidity data and algorithms that are added to the In-flight Management System to calculate turbulence. Humidity and turbulence data are then downlinked as part of the aircraft's normal air-ground communications. These increased and expanded data provide a new capability for National Weather Service (NWS) models, which improves forecasting. At the same time, these improved airborne data allow scientists to update the logic in the algorithms used in the weather processors. This data will be used to develop and test national-scale turbulence modeling efforts.

Convective Weather. Research is underway to improve convective weather forecasting to provide forecasts of storm cells. Forecasts range from short-term predictions of storm growth and decay (nowcasts) to longer-term predictions of convective storm activity. The goal is to improve today's forecasts from 30 minutes to 6 hours in advance.

Ceiling and Visibility. This research is aimed at providing short-term (up to 6 hours in advance) predictions of when the ceiling and/or visibility in a terminal area will allow routine instrument flight rules (IFR) operations to be resumed.

Model Development and Enhancement. This research effort focuses on improving the accuracy of numerical weather models that support aviation weather.

Wake Vortex. The primary objective of the FAA Wake Vortex program is to increase understanding of vortex behavior so that new wake vortex separation rules based on aircraft performance can be established to increase terminal capacity.

10.1.13 NAS-Wide Research, Engineering, and Development

Concept of operations (CONOPS) research is a cross-cutting activity that will be conducted to develop additional detail and to validate the CONOPS for the modernized NAS. Research will include identifying and validating task taxonomy, roles and responsibilities, information flows, and scenarios. Human-in-the-loop analyses of the scenarios associated with concepts that reassign tasks or roles and responsibilities will also be performed. Finally, fast-time simulations will be conducted to link human-in-the-loop results to NAS levels of traffic and complexity.

Evaluation and validation of the safety and environmental impacts associated with the CONOPS will be performed. The system modeling of the NAS and the CONOPS will be updated to improve operational performance analysis. This analysis will support all phases of operational and system development (i.e., concept development, concept validation, demonstration, and deployment). It will also significantly improve the economic assessment in the investment analysis process.

Research is required to support flexible airspace use and dynamic resectorization. Some factors that will be considered are use of analytic tools and development of performance measures for airspace utilization. Tools will be developed to evaluate airspace structure and sectorization during the day and to make adjustments as operational situations demand. Additional airspace considerations are to expand the oceanic and en route routing structures and make them flexible. In the terminal area, the goal is to expand the number of airport departure and arrival routes. Some research considerations are increased use of space-based navigation, late-descent flight profiles, and higher aircraft speeds when flying below 10,000 feet.

Research is required to establish operational infrastructure strategies based on availability and safety of services. The primary goal is to develop a fault-tolerant NAS design based on safety, risk, security, and economic analysis. Studies will be conducted to determine metrics for system safety and system performance parameters. Increased NAS automation will require studies to determine the proper level of information security.

A NAS software research and development program will investigate domain-specific software architecture to improve software reuse and reliability. The program will address software certification, especially safety-critical systems that use commercial off-the-shelf software.

The R,E&D program will further review the expanded use of remote monitoring and maintenance control that will include CDM for prioritizing preventive and restorative maintenance activities.

R,E&D activities are needed to support security services in the future NAS. This is associated with developing and implementing new hardware and software functionality and related processing and information flows. Known security approaches may not scale well, or they may not be appropriate for the NAS's mixed government-private composition. R,E&D security activities must also address the security impacts of planned NAS work and define the necessary enhancements.

An additional requirement for the modernized NAS is to research innovative methods to support investment decisionmaking by the FAA. Because of the deregulated nature and the diversity of the user community, the traditional investment method of cost-benefit analysis is becoming increasingly ineffective. A strategy that reduces uncertainty by considering the complex nature of the NAS and the service role of the FAA is needed. A major consideration is the cost-effectiveness of user avionics and the cost of the decision support systems required to support the CDM capability of the automated NAS infrastructure.

To contribute to the development and implementation of the 2005 NAS CONOPS and its supporting architecture, human factors research will be addressing issues implicit in the design of new systems and procedures. Research in this area will define changes to operational concepts, and human factors research will provide information concerning the feasibility of these operational changes.

The research and development activities regarding separation standards and assurance will contribute to safe separation of air traffic. The primary goal of separation standards research is to provide decisionmakers with quantitative guidance for establishing and maintaining safe separation standards. The secondary goal of this research is to provide decisionmakers with tools to assess the value of changing separation standards. Methodologies will be developed to determine minimum safe separation criteria. The process will account for the performance of situational awareness systems, such as navigation, communication, surveillance, and decision support systems. Additionally, operational factors such as traffic flows, ATC, and cockpit human factors will be accommodated, and uncontrollable influences such as weather and in-flight emergencies will have to be considered.

Research will consider the adaptation of international standards for reducing vertical separation to 1,000 feet between aircraft flying above 29,000 feet. Additional research will be needed to develop the requirements for transferring safe separation assurance responsibility from ATC to the cockpit under certain situations. The benefits and costs of reducing or changing separation standards also need to be assessed.

10.2 Airports Technology

The Airports Technology R,E&D mission is to provide solutions that will allow the nation's airports to accommodate the projected traffic growth cost-effectively and safely. See Section 11, Regulation and Certification Activities Affected by New NAS Architecture Capabilities, for more details.

Airport technology R,E&D programs develop new standards and criteria for airport planning, design, construction, operation, and maintenance. Research into visual guidance systems will enhance airport ground operations at night and during low-visibility conditions. Improvements in airport lighting, signs, and markings will help eliminate runway incursions. Airport research includes:

- Airport planning and design research, which produces aircraft/terminal compatibility analyses, design standards for terminals, design standards for multiple/parallel runways, and user guides for airport operators and industry
- Airport pavement technology research, which provides 3-dimensional, finite element models for airport pavement design, national pavement test machine, and data base of in situ airport pavement performance
- Airport safety technology research, which provides technical data supporting runway

maintenance regulations and advisory circulars; design specifications for fire training facilities; design criteria for airport, heliport, and vertiport lighting and markings; technical data on firefighting agents and vehicles; and technical data and advisory circulars on wildlife habitat management, bird harassment techniques, and landfills.

10.3 Aircraft Safety

R,E&D includes research in a wide range of areas related to the safety of aircraft, crew, and passengers. The R,E&D program develops technology, technical information, tools, standards, and practices to ensure the safe operation of the civil aircraft fleet within a safe global air transportation system. The program focuses on eliminating hazards to a safe air transportation system, both to prevent accidents and to mitigate the effects of any accidents that do occur. See Section 32, FAA Regulatory Mission, for more details.

Aircraft safety R,E&D programs develop new technologies to improve NAS safety and provide the FAA's Regulation and Certification organization (AVR) with the necessary information to carry out its mission. These programs address the many hazards that face all aircraft, as well as special hazards endemic to certain segments of the civil aircraft fleet. For example, older aircraft are susceptible to structural problems caused by metal fatigue and corrosion; newer aircraft, with digital flight controls and imbedded software, are susceptible to electromagnetic interference. The major aircraft safety programs include:

- Aviation safety risk analysis, which has resulted in the safety performance analysis system and the system for identifying aircraft certification risks
- Fire research and safety, which has led to requirements for non-halon fire-extinguishing agents, fire-hardened fuselage structures, fire-safe emergency oxygen systems, fire-resistant materials for cabin interiors, and cabin safety/benefit analysis models
- Advanced material/structure safety research, which is responsible for the handbooks on composite technologies and manufacturing/inspection analysis techniques, data packages on certification of structures made from advanced materials and on seat restraint systems, and technical data on crash-resistant auxiliary fuel system designs
- Propulsion and fuel systems work that has resulted in probabilistic engine rotor design code, specifications for titanium alloys, and certification standards for unleaded fuels
- Flight safety/atmospheric hazards research that led to aircraft surface-ice detection technologies and systems, electronic threat definition and validation, and technical data on digital technology for flight-critical systems
- Aging aircraft program work that has enabled the development of analytical tools and models to assess commuter and transport aircraft structural integrity and repairs.

Human factors research is used to improve:

- Systems design
- Certification and regulation decisions
- Operating directives
- Training procedures.

Human performance remains a critical part of safe and efficient NAS operations. Advances in technology have increased the reliability of most NAS components; however, the number of accidents and incidents attributed to human error has remained constant. AVR's human factors programs support the National Plan for Civil Aviation Human Factors by addressing priority areas such as aircrew performance, aircraft maintenance, and aircraft cabin environment. Human factors research includes:

- Research into the flight deck and aircraft maintenance areas that led to the development of human factors guidelines to reduce automation-related errors
- Flight deck/ATC system integration work that resulted in human factors guidelines for computer-human interface applications and the ability to assess human performance in a highly integrated/automated environment
- Aeromedical research that led to quantitative bioengineering criteria for aircraft evacuation, flotation devices, and other rescue equipment.

10.4 Human Factors and Aviation Medicine

The Human Factors and Aviation Medicine program identifies methods that help reduce the fatal accident rate; ensures human factors issues are addressed in the acquisition and integration of FAA aviation systems; and develops recommendations for protective equipment, procedures, standards, and regulations to protect all aircraft cabin occupants. Human factors research will increase NAS safety and efficiency by developing scientifically validated information and guidance for improving the performance and productivity of air traffic controllers and NAS system maintenance technicians. The Human Factors program addresses operational requirements through research in the areas of Human-Centered Automation, Selection and Training, Human Performance Assessment, Information Management and Display, and Bioaeronautics. For more details, see Sections 8, 15 through 27, and 32.

10.5 Aviation Physical Security

The main goal of the Aviation Security program is to mitigate the terrorist threat to the civil aviation system. Through the Aviation Security R,E&D program, the FAA promotes development of technologically improved products in explosive detection, aircraft hardening, airport security, and human factors. Products from the R,E&D program include explosive detection systems and devices, technologies, specifications, and technology integration plans. See Section 32 for more details.

Civil aviation security is focused on countering increasingly sophisticated threats to civil aviation. The spread of terrorism makes it imperative that the FAA develop effective countermeasures. Emphasis is on developing automated capabilities to prevent explosives from being carried onto aircraft and on enhancing human performance. Research also includes devising test protocols and performance criteria for automated explosives detection systems. Civil aviation research includes:

- Explosives/weapons detection research that has developed trace and bulk personnel screening portals and certification of trace electronics screening systems
- Aircraft hardening research that provides guidelines for blast mitigation/aircraft hardening, design specifications for aircraft and support equipment, and threat assessments on advanced terrorist weapons
- Airport security technology research that provides airport vulnerability reports and analytic models for threat, risk, and vulnerability assessment
- Aviation security human factors research that produces human systems integration analyses, reports on explosives and weapons detection technologies, and automated profiling systems.

10.6 Environment and Energy

The Environment and Energy R,E&D program identifies, controls, and mitigates environmental consequences of aviation activity. The program is composed of three major disciplines, including aircraft noise reduction and control, engine emissions reduction and control, and aviation environmental analysis. These disciplines form a cohesive focus of research projects to support federal actions regarding noise and engine exhaust emissions. See Section 30 for more details.

10.7 Program Management

The Program Management R,E&D program provides for effective and responsible stewardship of funds entrusted to the FAA for research and development by NAS users. Effective stewardship of the R,E&D program requires that NAS users receive the best possible program for their investment. Participants ensure that the correct research is performed, the necessary provisions are made in the budget and planning process, and the highest standards of financial accountability are rigorously maintained.

Additionally, the program must fund no research that duplicates work being performed elsewhere, particularly with National Aeronautical and Space Administration (NASA) funding. The FAA has and will continue to work with other agencies, including NASA and DOD, to leverage research dollars in the search for common solutions to problems affecting aviation.

10.8 Summary

Understanding what role new and emerging technologies play in NAS modernization and how to best adapt these technologies to increase NAS efficiency and safety are key elements in implementing this architecture. Working with industry and other government agencies, the FAA will leverage scarce resources to maximize potential benefits.

The transition of research funding from R,E&D to F&E appropriations has created a direct linkage between research and capital investment. Much of the research identified in the *National Airspace Architecture Version 4.0* will need to rely on funding by public/private partnerships, industry investment, and the developing consensus on the role and funding level for research within the FAA and NASA on aviation research.

11 REGULATION AND CERTIFICATION ACTIVITIES AFFECTED BY NEW NAS ARCHITECTURE CAPABILITIES

The FAA's regulation and certification mission is carried out primarily by the Regulation and Certification (AVR) organization. AVR is responsible for aircraft and aircraft component certification, continued airworthiness monitoring and inspection, and new or revised flight regulations that change operating procedures. The other FAA organizations that perform regulation and certification activities related to their primary mission are Air Traffic Services (ATS) and Research and Acquisitions (ARA).

ATS is responsible for ground-based equipment acceptance and certification. It also revises controller operational procedures and orders as necessary to achieve the full benefits of the modernization effort. Most ground-based systems described in the NAS architecture will have an ATS acceptance and certification requirement.

ARA develops initial functional and performance specifications for products with the sponsoring organization during the Integrated Product Team process. If the system produces electromagnetic signals, the Office of Spectrum Policy and Management (ASR) develops additional performance specifications, such as what portion of the radio frequency spectrum the system will use and parameters for radio frequency interference protection. Prior to system implementation, ARA conducts initial evaluations to ensure products meet requirements.

For NAS architecture purposes, the FAA's regulation and certification activities can be divided into three broad categories: ground-based components, airborne components, and procedures/rulemaking. However, certification processes may vary on a case-by-case basis. That is, each product has a unique set of variables that affect the length of the certification process. Following is a high-level discussion of the complex, cross-organizational certification mechanisms required by the FAA.

11.1 Ground-Based Components

Most of Part III, NAS Architecture Description, addresses ground-based air traffic control systems that the FAA will acquire as part of NAS modernization. The organizations responsible for ground-based equipment acceptance and certification are determined by the equipment's function and intended use. Some systems may require acceptance and certification from both the Airway Facilities Service (AAF) and Air Traffic Service (AAT);[1] others may require action by only one. For example, the Host/Oceanic Computer System Replacement (HOCSR) described in Sections 21, En Route, and 22, Oceanic and Offshore, will require AAF acceptance and certification for initial operating capability (IOC) based on specific parameters developed for this equipment. Typically, one formal parameter to declare IOC involves having technicians properly trained in system maintenance. Transition from IOC to operational readiness demonstration (ORD) is the responsibility of AAT.

The transition to ORD typically involves a period of dual operation of the old and new systems so that personnel can gain confidence and operational experience with the new equipment. Although the HOCSR, for example, probably will not require any specific controller training, training for other infrastructure systems is an important requirement that must be satisfied before the transition to ORD can begin. ATS will also be responsible for any changes to procedures enabled or required by the new system (see paragraph 11.3, Procedures/Rulemaking, for further discussion).

11.2 Aircraft Components

Many of the new capabilities and modernization efforts described in the NAS Architecture Version 4.0 depend on equipping aircraft with certified avionics. AVR is responsible for all airborne certification and procedural regulatory activities. Within AVR, the Aircraft Certification Service staff is responsible for certification related to de-

1. The Airway Facilities Service (AAF) and Air Traffic Service (AAT) are sub-organizations within the Air Traffic Services (ATS) organization.

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sign, production, and installation approvals for aircraft, aircraft modifications, and aircraft appliances as well as for monitoring manufacturers after approvals are issued. Specialists in aircraft certification offices (ACOs) located throughout the United States perform certification approval and manufacturer monitoring. The applicants are ultimately responsible for demonstrating to the FAA ACO representatives that their designs comply with all applicable federal regulations. In general, certification processes lead to the same three required approvals: design approval, production approval, and installation approval.

Several methods are used to certify aircraft equipment such as avionics, but these methods only apply to aircraft that have Type Certificates. Avionics can be certified through an Amended Type Certificate, Parts Manufacturer Approval, Technical Standard Order Authorization, Supplemental Type Certificate, Form 337 Field Approval, or approval under an Operating Certificate (the airline equivalent of a Form 337 Field Approval).

Certificated aircraft have a Type Certificate and Production Certificate based on the approved type design drawings and specifications that define the configuration and design features of the product, including avionics equipment. For new avionics, the Type Certificate holder may elect to follow a process that amends the Type Certificate and Production Certificate to gain the design, production, and installation approvals for that aircraft model. The extent of the change determines how simple or complex the amendment process needs to be.

The Parts Manufacturer Approval and Technical Standard Order Authorization processes give manufacturers design and production approvals for their products, but do not provide an installation approval. The installation approval is subsequently granted through a Supplemental Type Certificate, Form 337 Field Approval, or under an Airline Operating Certificate.

The difference between a Parts Manufacturer Approval and Technical Standard Order Authorization is the certification basis. A Parts Manufacturer Approval is granted based on test reports and computations conducted under an FAA-approved and -supervised test plan; identicality with a previously certified article; or a licensing agreement from a Type Certificate or Supplemental Type Certificate holder. For a Technical Standard Order Authorization, the FAA establishes minimum performance standards for the general equipment item (i.e., radios, the Global Positioning System (GPS), transponders, etc.), and the applicant submits material for FAA review demonstrating that their product meets the standards.

The Supplemental Type Certificate process is used to grant any one or all three required certification approvals (design, production, installation) for changes to a Type Certificated product. A Supplemental Type Certificate (STC) is only valid for a specific aircraft (one-time STC) or a specific aircraft make and model (multiple STC). To receive an STC, applicants must provide data proving the Type Certificated product still complies with its applicable certification basis. The complexity of the STC process depends on the extent of the change being requested.

The Form 337 Field Approval process typically involves a Flight Standards Service representative[2] certifying that the alteration complies with regulations and conforms with accepted industry practices. The three elements of this process are approval of data, conformity of installation, and approval to return the aircraft to service. Approval can be accomplished through an engineering review, by physical inspection and testing, or by demonstration. Field Approvals usually apply to one specific aircraft and require relatively less design data for substantiation than the other certification processes. The extent of the alteration determines if the Field Approval process can be used or if one of the other certification processes is needed.

11.3 Procedures/Rulemaking

NAS operations are governed by a complex set of procedures and rules that determine controller and pilot actions. The new equipment and concepts described in this document will have little or no effect on the NAS until both controllers and pilots have approved procedures that enable a change in operations. In some cases, the NAS architecture

2. The Flight Standards personnel may receive support from Aircraft Certification Service engineers or manufacturing inspectors if needed.

will also require airspace structure revisions before the projected benefits can be realized.

11.3.1 Controllers

ATS develops controller procedures for ground-based air traffic control (ATC) components of NAS modernization. FAA Order 7110.65, Air Traffic Control, describes services provided by controllers, safety standards that must be maintained, and standardized methods to accomplish controller tasks. However, many of the new concepts, such as Free Flight, fall outside the current boundaries of 7110.65. If no changes are made to procedures, controllers will be limited to using the new equipment for traffic separation in much the same way they used the equipment that was replaced. This could severely limit the benefits from modernization efforts and prevent final implementation of new concepts such as Free Flight.

ATS is also responsible for airspace redesign. Today, changes to airspace design are usually done at the local level by the air traffic facilities that require a change. Typically, only refinements that do not drastically alter the airspace configuration around the facility are made to the existing structure. However, new capabilities for air traffic control proposed in the architecture may require strategic, systemwide changes to the airspace structure.

Without new controller procedures and changes to the current airspace structure, new NAS capabilities will not be fully exploited, and the intended benefits will not be realized. Future versions of the architecture will need to address in greater detail how, when, and what changes to controller procedures and airspace design are needed for the future NAS as part of a fully integrated modernization plan.

11.3.2 Pilots

The Flight Standards Service develops basic operating procedures for pilots established in selected parts of 14 Code of Federal Regulations (CFR). Airlines may supplement these regulations with FAA-approved company operating procedures. Many new capabilities will require new avionics in aircraft before benefits are realized. Accordingly, regulations will need to be revised or new regulations created so that pilots can use new avionics fully.

Table 11-1 is a preliminary summary of current regulations in 14 CFR, Parts 1 through 1273, that are affected by the baseline architecture capabilities. The preliminary assessment has identified 11 regulations that will require modification. Full descriptions of the capabilities listed in Table 11-1 appear in Section 5, Evolution of NAS Capabilities, and Appendix D, NAS Capabilities and Matrix.

For systems implemented in the near term, affected regulations will generally require only modest wording changes. However, in many instances, the existing regulations do not address the new capabilities described in the architecture, such as direct routing or cockpit display of traffic information for air-to-air surveillance. Therefore, new regulations will be required before longer-term concepts and systems can be implemented. In particular, the existing regulations will have to be expanded, or new regulations written, to establish minimum avionics equipage requirements relative to airspace class[3] and type of operation.[4] Additionally, procedures will have to be established for both controllers and pilots that detail how aircraft with varying equipage levels will be accommodated when operating in the same airspace.

Creating or changing regulations is a complex, time-consuming process. By law, there are sequential steps and mandatory comment periods that must be observed before a rule becomes final. Simple changes or rules that do not generate a great deal of comments can be processed in 12 to 18 months. However, it can take 3 to 4 years for a final rule to be issued if it entails major changes that generate many comments from the aviation community. It is reasonable to assume that any rulemaking actions resulting in significant operational changes or minimum equipage requirements will generate intense interest from the aviation community.

3. Refers to class A,B,C,D,E, and G airspace.
4. Visual flight rules, instrument flight rules, 14 CFR Part 91, 121, 135, etc.

11.4 Summary

The full range of benefits projected by the NAS architecture will not occur without new or revised aircraft operating regulations with complementary controller procedural changes and airspace redesign. These are complex issues that will be addressed in the architecture through a cooperative effort of the FAA and the aviation community.

Table 11-1. Preliminary Analysis of Regulations Affected by the Baseline Architecture (Sheet 1 of 2)

Capability Title	Federal Aviation Regulation (FAR) Part									
	1.1	1.2	61.63	71.75	71.901	91.205	121.349	129.17	147 Appendix C	170.3	171 new Subpart K
Initial WAAS Precision Approach Existing Airports	X	X	X	X	X	X	X	X	X	X	X
WAAS Precision Approach New Qualifiers	X	X	X	X	X	X	X	X	X	X	X
GPS Oceanic	X	X		X	X	X	X	X	X	X	
Terrain Avoidance	X	X				X			X		
Initial WAAS Cruise	X	X	X			X	X	X	X	X	X
LAAS Cat I	X	X	X	X	X	X	X	X	X	X	X
LAAS/Cat II/III	X	X	X	X	X	X	X	X	X	X	X
ITWS Stand Alone	X	X				X			X		
Initial TWIP	X	X				X			X		
Expanded TWIP	X	X				X			X		
MDCRS	X	X				X	X	X	X	X	
Enhanced MDCRS	X	X				X	X	X	X	X	
Initial FIS	X	X				X			X		
Automatic Simultaneous Weather Notification	X	X				X			X		
Improved Terminal Surveillance (ASTERISK/SI)	X	X				X			X		
Runway Incursion Reduction	X	X				X		X	X		
Integrated Terminal Surveillance with ADS-B	X	X				X	X	X	X	X	
Integrated En-Route Surveillance with ADS-B	X	X				X	X	X	X	X	
Improved En-Route Surveillance (ASTERISK/SI)	X	X				X	X	X	X	X	
Integrated Tower Area Surveillance	X	X				X	X	X	X	X	X
Air-Air ADS-B	X	X				X	X	X	X	X	X
TIS via Mode-S	X	X				X			X		
ADS-B Gap Filler	X	X				X			X		
Ocean Surveillance via ADS-A	X	X				X	X	X	X	X	X
TDLS	X	X				X			X		
CPDLC Build 1	X	X				X			X		

Table 11-1. Preliminary Analysis of Regulations Affected by the Baseline Architecture (Sheet 2 of 2)

Capability Title	Federal Aviation Regulation (FAR) Part									
	1.1	1.2	61.63	71.75	71.901	91.205	121.349	129.17	147 Appendix C	170.3	171 new Subpart K
CPDLC Build 1A	X	X				X			X		
Oceanic Data Link	X	X				X	X	X	X		
Multi-Sector Oceanic Data Link	X	X				X	X	X	X		
Expanded TDLS	X	X				X			X		
CPDLC Build 2 via VDL Mode-2	X	X				X		X	X	X	
CPDLC Build 2 via VDL Mode-3	X	X				X		X	X	X	
CPDLC Build 3 via VDL Mode-3	X	X				X		X	X	X	
NAS-Wide Data Link	X	X				X		X	X	X	
Interactive Airborne Refile	X	X				X		X	X	X	
aFAST with Wake Vortex	X	X				X		X	X		
RVSM/50 Lateral	X	X				X	X	X	X	X	
50/50	X	X				X	X	X	X	X	
SMS	X	X				X		X	X		
Low-Altitude Direct Routes—Using WAAS	X	X	X	X	X	X	X	X	X	X	X
Low-Altitude Direct Routes—Expanded Radar Coverage	X	X	X	X	X	X	X	X	X	X	X
Low-Altitude Direct Routes—Expanded Surveillance Coverage	X	X	X	X	X	X	X	X	X	X	X
NAS-Wide Information Sharing	X	X				X		X	X		
ELT for SAR and Flight Following	X	X				X		X	X		

12 PERSONNEL

As in most major service organizations, people are the NAS's greatest asset. Thousands of people operate the equipment used to provide NAS services to the aviators and passengers each day. The FAA employs over 47,000 people. FAA operations personnel include 17,000 operational controllers, 3,500 flight service personnel, and 8,000 maintenance personnel located at NAS sites throughout the United States. The user group includes 650,000 pilots operating more than 280,000 commercial, regional, general aviation, and military aircraft, and 2,000 manufacturers.

FAA personnel include air traffic controllers, operational controllers, flight service specialists, maintenance engineers, safety and security inspectors, environmental specialists, systems and software engineers, operations research analysts, human factors specialists, business managers, and scientists, as well as individuals skilled in a number of other disciplines.

These personnel are located at the FAA Headquarters in Washington, D.C., FAA towers, FAA air route traffic control centers (ARTCCs), and flight service stations. Air Traffic Services, which provides the majority of FAA personnel, is comprised of Air Traffic (AT), Airway Facilities (AF), Air Traffic System Requirements, System Capacity, and Independent Operational Test and Evaluation.

12.1 Factors Affecting Staffing Levels

Three primary factors affect staffing levels and costs assumed in the architecture: anticipated growth in air traffic operations, union contracts, and deployment of the NAS infrastructure management (NIM). A discussion of the effects of these changes follows.

Traffic Growth

According to FAA forecasts, worldwide aviation growth tracks with economic growth. Passenger traffic, domestic enplanements, and international enplanements are forecast to increase annually. Aircraft operations are forecast to grow at a rate of 2.0 percent per year from 1994 to 2006.[1] The growth is assumed to continue at the same rate from 2007 to 2015. Consistent with the AT staffing plan projections, center and tower/TRACON controller staffing levels will increase at a rate of 0.75 percent per year from 2003 through 2015.

As the NAS modernizes, workforce requirements and changes will need to be incorporated with a long-term view. The NAS Sustainability Core Team determined that greater efficiencies and required skill sets will be sought by users and Congress that are not in place today. Staffing knowledge, skills, and abilities of the future workforce will change as major programs are implemented. Airway Facilities positions will require increased knowledge of computer systems, software applications, air traffic operations, and NAS service management, as well as satellite and digital technology. Although no significant changes are needed in major functions performed, staffing, training, and hiring required to support mission needs should be identified early.

Union Contracts

The new labor agreement recently reached with the National Air Traffic Controllers Association (NATCA) includes a reclassification of air traffic control (ATC) facilities from 5 categories to 12. The effects of this reclassification on the total number of controllers required and their associated costs have not been considered for this architecture. *Contract negotiations are currently underway with the Professional Airways Systems Specialists (PASS). Any changes to staffing levels or costs are not included in this version of the architecture.*

NAS Infrastructure Management (NIM)

NIM is a centralized management concept for the NAS infrastructure, with maintenance control centers distributed throughout the country. Transitioning to operations control centers (OCCs), implementation of remote maintenance monitoring capability, and changes in the maintenance philosophy will improve performance. The envisioned maintenance philosophy calls for deleting the incumbent contractor maintenance and implementing in-house field and software maintenance.

1. Source: *Federal Aviation Forecasts*, Fiscal Years 1997–2008.

NIM tools deployment will result in part of the AF workforce (personnel who are not directly assigned to systems) remaining constant. Initial staffing reductions have occurred in anticipation of NIM tools deployment. Immediate effects will apply to field maintenance specialists, computer operators, and the Operational Support Service (AOS) workforce.

12.2 Assumptions

Personnel Costs

The personnel funding in this section includes personnel salaries and benefits. Other related expenses associated with personnel—such as rent, utilities, travel, training, and change-of-station funding—appear in Section 31, Mission Support. Funding for system field specialists is included in the systems' Operations (OPS) funding lines.

The yearly expense for each person on the FAA payroll is projected to grow faster than inflation. Based on past trends, the expense of a controller grows at 3 percent per year above inflation, and the expense of non-controller workforce personnel grows at 1.5 percent per year above inflation. This growth, when compounded annually, causes considerable growth in OPS funding requirements.

Personnel Categories and Costs

Personnel funding is appropriated for the following categories under Research, Engineering, and Development (R,E&D), Facilities and Equipment (F&E), and OPS:

R,E&D

- *Personnel, Compensation, Benefits, and Travel (PCB&T, R,E&D):* Includes all personnel paid by R,E&D funding.

F&E

- *Personnel, Compensation, Benefits, and Travel (PCB&T, F&E)*: Includes FAA Headquarters acquisition personnel and airway facilities installation staff paid by F&E funding.

OPS

- *Air Route Traffic Control Center Personnel (ARTCC-P)*: Includes the controller workforce at air route traffic control centers (ARTCCs). These individuals guide and direct the aircraft traffic from gate to airport surface, takeoff, and landing and flight within 40 miles of airports.

- *Airport Traffic Control Tower Personnel (ATCT-P)*: Includes the controller workforce at air traffic control towers (ATCTs) and terminal radar control (TRACON) facilities.

- *Air Traffic Planning, Development, and Evaluation Personnel (PDE-P)*: Includes non-controller workforce air traffic personnel located at FAA Headquarters and in centers, towers, and terminal radar approach control (TRACON) facilities who perform the following functions: planning, directing and evaluating; administration; and system capacity analysis.

- *Flight Service Station Personnel (FSS-P)*: Includes flight service personnel. These individuals provide preflight and in-flight weather information for millions of general aviation flights in addition to filing the flight plans for those flights. Further, flight service personnel help customs activities with aviation border crossings and preliminary support for search and rescue for potentially downed aircraft.

- *FAA Headquarters Personnel (FAAHQ-P)*: Includes staff who perform the following functions: aviation regulation and certification, security, safety, acquisition, commercial space applications, airport administration, general administration, medical, and general counsel.

- *FAA Logistics, Flight Inspection Personnel (FAALFI-P)*: Includes flight inspectors and logistics personnel.

- *Airway Facilities Non-System (Non- Sys)*: Includes Airway Facilities Headquarters staff and regional and other staff not assigned directly to systems.

- *System Level Maintenance Workforce*: This level of personnel for specific systems maintenance is in the OPS and is not identified as a separate category in this section. Approximately 20 percent of the current FAA workforce maintains the ATC system.

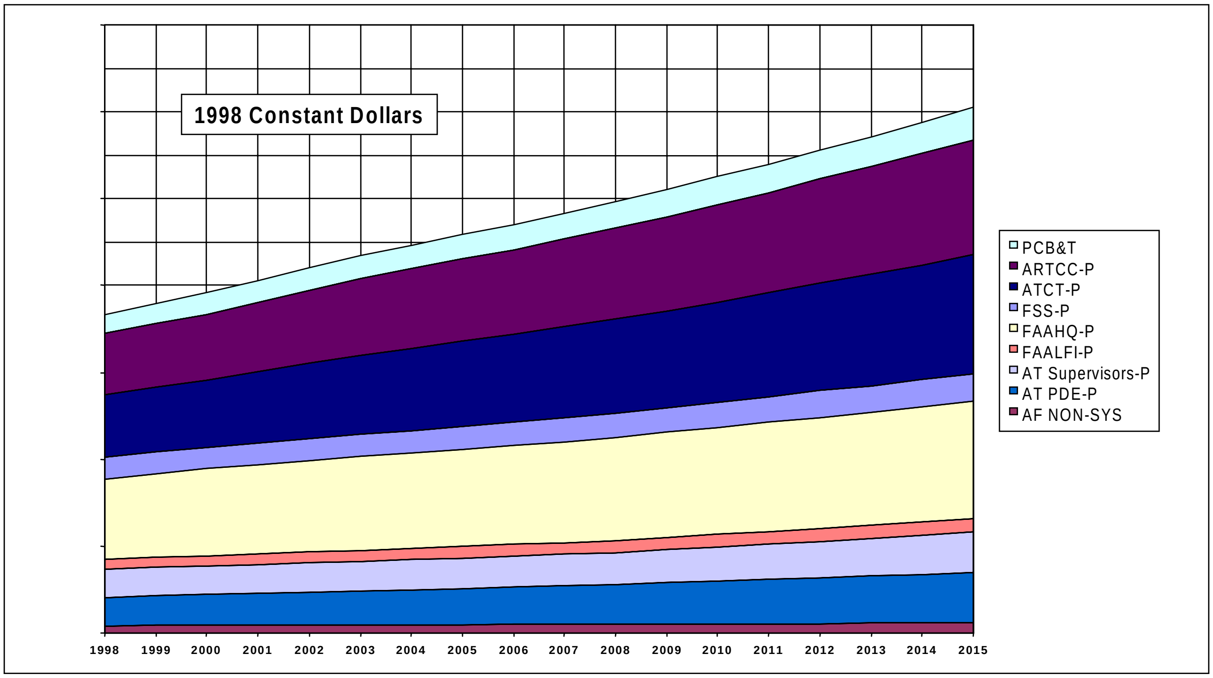

Figure 12-1. Estimated Personnel Costs

Staffing Levels

Figure 12-1 shows total personnel costs for both F&E and OPS by fiscal year, except for the AF systems field specialists whose positions are dedicated to maintaining specific systems. (The funding for those positions is included with OPS funding for the specific systems they support.) Total personnel costs forecast for 2015 are 30 percent higher than in 1998.

12.3 Watch Items

The effects of the labor agreement with the National Air Traffic Controllers Association (NATCA) in late 1998 reclassified air traffic control facilities. Contract negotiations with PASS have not been factored into this architecture.

12.4 Summary

As the architecture is implemented, the types and numbers of personnel required to operate and maintain the NAS should be reviewed and adjusted as necessary. Investigation into potential cost saving due to FAA staffing level reductions continues.

13 COST OVERVIEW

Costs for executing this architecture are based on full life-cycle costs for fielding, operating, and/or maintaining current systems and projected costs, including acquisition for future systems. NAS modernization costs include training, procedures development, regulation changes, and certification requirements. The funding levels described in the NAS Architecture Version 4.0 ensure continued safety for the flying public and growth of system capacity. Total costs by funding category are provided, except for Airport Improvement Program (AIP) funds, which are not currently integrated into the NAS architecture.

The primary cost is for air traffic management services (i.e., the process of efficiently clearing aircraft from origin to destination while maintaining safety). Other costs include:

- Safety:
  - – Safety inspection of aircraft
  - – Certifying new aircraft and avionics
  - – Testing and certifying pilots
- Capacity:
  - – Disseminating information to airspace users
  - – Maintaining the NAS infrastructure
  - – Introducing new technologies
  - – Strategic planning for future operations
- Security:
  - – Maintaining security at airports and FAA facilities and in flight
- Environment:
  - – Responding to environmental issues.

All costs represented in this document indicate fiscal year (FY) costs from 1998 through 2015.

13.1 FAA Funding Appropriations

The FAA receives four different types of appropriations from Congress each year: Research, Engineering, and Development (R,E&D); Facilities and Equipment (F&E); Operations (OPS), and AIP. Figure 13-1 shows total FY R,E&D, F&E, and OPS costs (escalated for inflation) associated with the architecture, which are based on the FAA's January 1998 funding projections through 2015.

13.1.1 Research, Engineering, and Development Funding

R,E&D activities minimize the risks associated with capital expenditures; focus research in areas with a high potential for success, such as joint re-

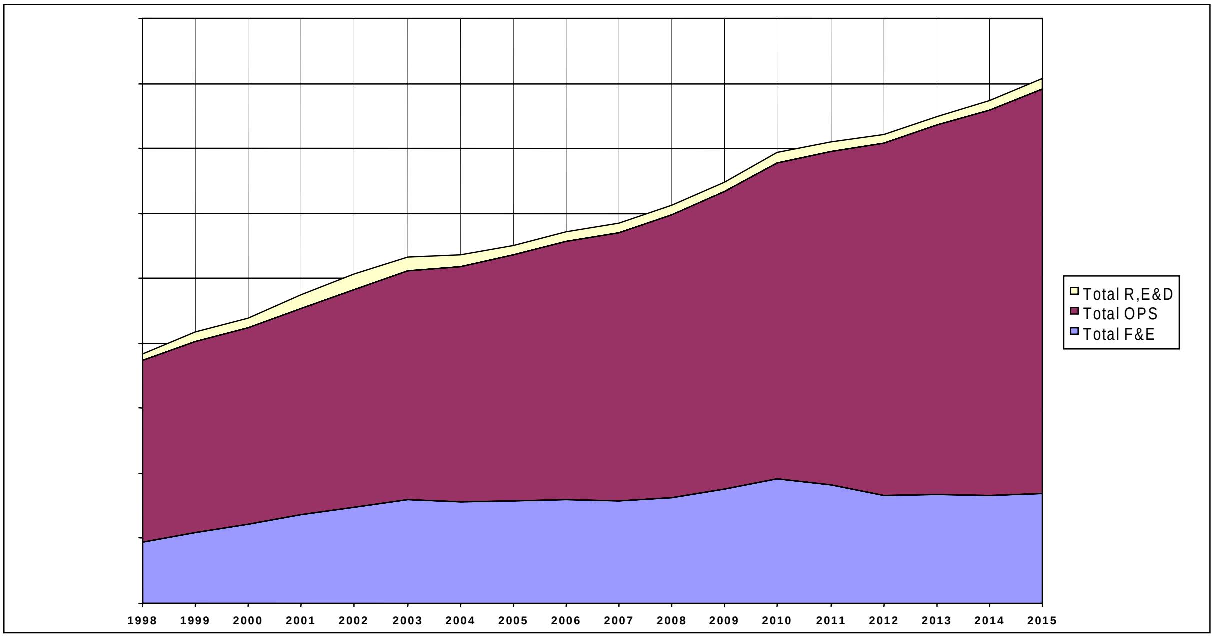

Figure 13-1. Estimated NAS Architecture Costs

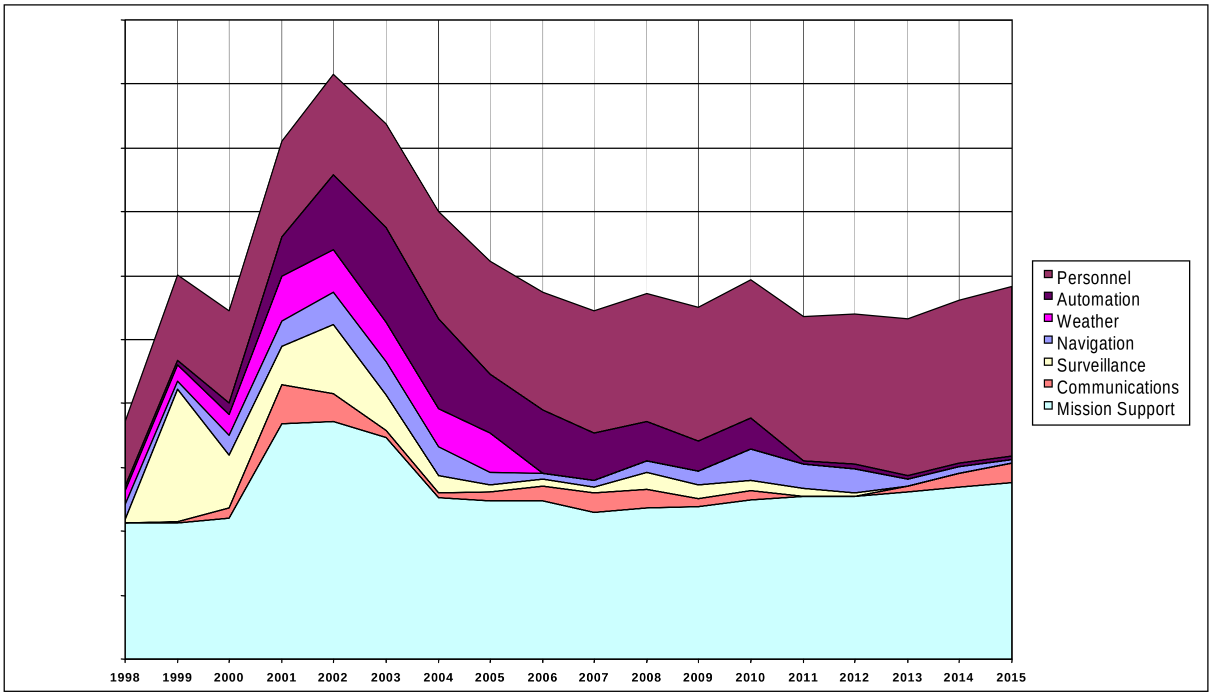

Figure 13-2. Estimated R,E&D Costs

search with the National Aeronautics and Space Administration (NASA) for future avionics; and research aviation-unique disciplines (e.g., aircraft fire safety). Figure 13-2 shows the estimated R,E&D funding requirements associated with the architecture. The FAA and NASA sponsor joint research projects; however, NASA research funding is not included in Figure 13-2.

The R,E&D funds required in the early years of NAS modernization (from 1999 through 2004) are significant because implementing a smooth, low-risk NAS transition depends on research. This R,E&D provides the foundation for projects that will implement the Government/Industry concept of operations (CONOPS). For more detailed information about R,E&D activities, see Section 10, Research, Engineering, and Development.

13.1.2 Facilities and Equipment Funding

Figure 13-3 shows the minimum estimated F&E funding required to implement the NAS architecture. F&E required in the financial baseline (from 1999 through 2004) is vital because a significant amount of equipment replacement and infrastructure refurbishment has been delayed due to the previous lack of funds. The FAA must modernize, repair, and replace a significant portion of its infrastructure in the near future to sustain current services and also to provide new capabilities and services to meet user needs. Delaying infrastructure replacement will cause increases in the OPS funding for maintaining equipment. Historically, systems reaching the end of their economic service lives fail more often and require increased maintenance. In addition, it is difficult, costly, and sometimes impossible to add functional enhancements to these older systems.

The gradual increase in F&E funding is shown in Figure 13-1. Additional future user needs will also emerge over time, which could increase funding requirements.

13.1.3 Operations Funding

OPS funding and estimated requirements are shown in Figure 13-4. Investing capital can save operating expenses. The architecture considers this, but as new systems are deployed, the total OPS cost for a service increases until its transition period is complete, the older equipment is removed from service, and the site is environmentally restored. This is most dramatically demonstrated in the navigation functional area with the deployment of the augmentation systems for satellite-based navigation and landing and the gradual phase-down of the ground-based navigation

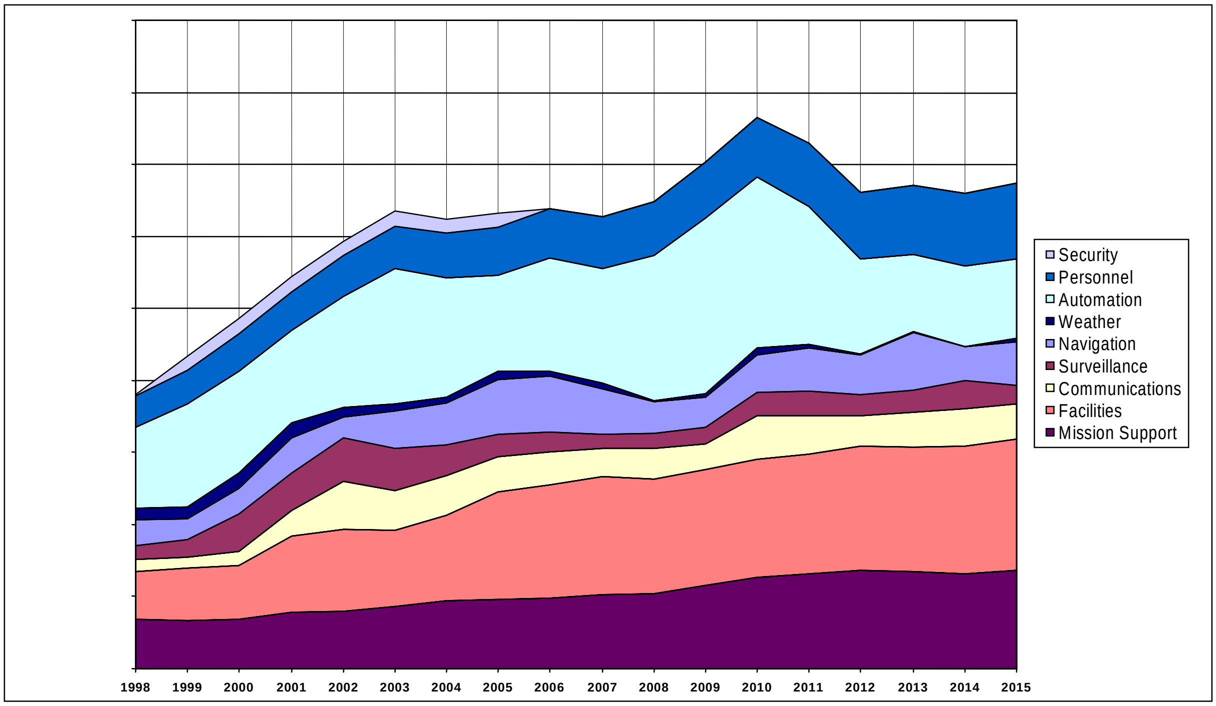

Figure 13-3. Estimated Architecture F&E Costs

and landing systems (see Section 15, Navigation, Landing, and Lighting Systems).

To implement the concepts of Free Flight, the FAA must increase the services it provides to NAS users. This is best demonstrated in the expansion of communications and information-sharing activities. Even though unit prices for communications and commercially available computer processors (like desktop personal computers) are decreasing, the FAA's use of and reliance

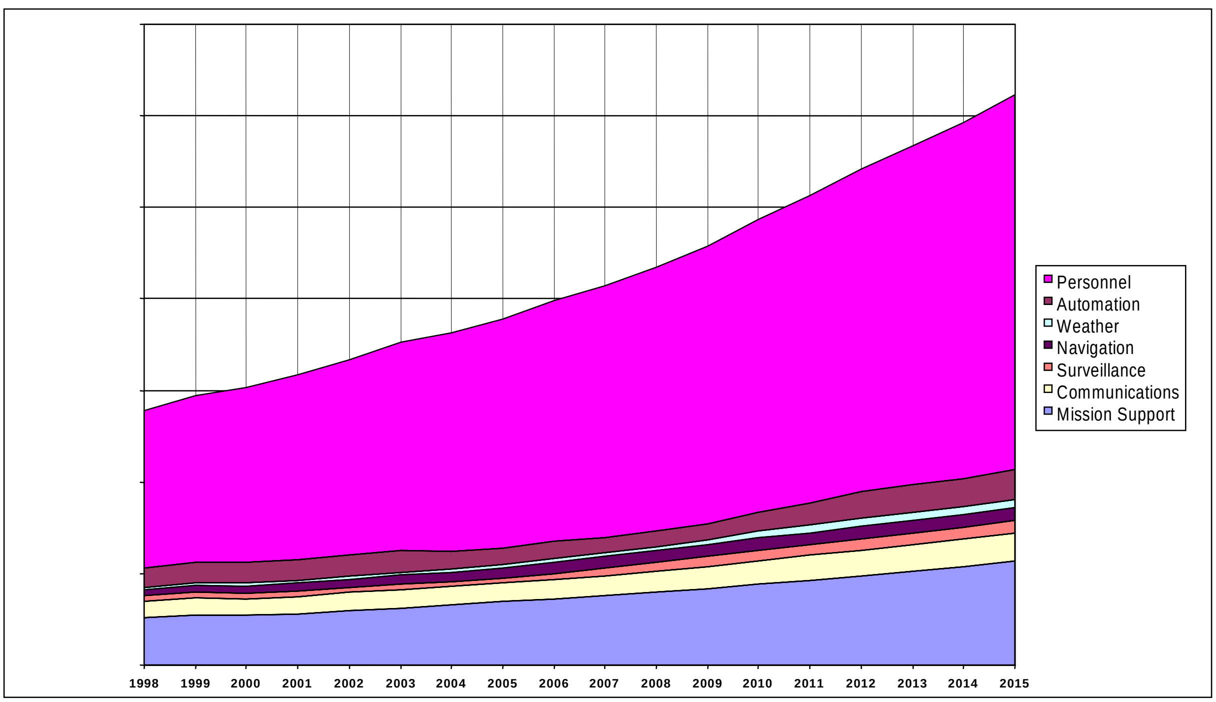

Figure 13-4. Estimated Architecture OPS Costs

PART II

on these items is increasing, and therefore, the total OPS cost to provide services will rise.

Operating the NAS is personnel-intensive; therefore, the dominating cost element is personnel cost (see Figure 13-5). Personnel account for approximately 70 percent of operations costs (see Section 12, Personnel). As traffic and services increase more FAA personnel (controllers, traffic managers, technicians, inspectors, etc.) may be needed.

13.1.4 Airport Improvement Program Funding

AIP funds are primarily airport improvement grants given to various qualifying airports. Airports use the money to help modify or add runways, relocate utilities, or even buy land around the airport to ensure environmental compliance for noise restrictions. Currently, AIP funding is not included in the architecture cost profiles. In FY99, work will focus on integrating airport development needs into the architecture. See Section 28, Airports, for additional information. The FAA will continue to fund approach lighting and landing aids based on current criteria.

13.2 User Avionics Costs

For NAS modernization to be realized, aircraft need to equip with new avionics. The costs for avionics required by NAS modernization, as well as the transition/implementation periods, have been estimated. The estimates were developed by the FAA working in conjunction with avionics manufacturers, aircraft manufacturers, airlines, and general aviation organizations. These costs are discussed in Section 18, Avionics.

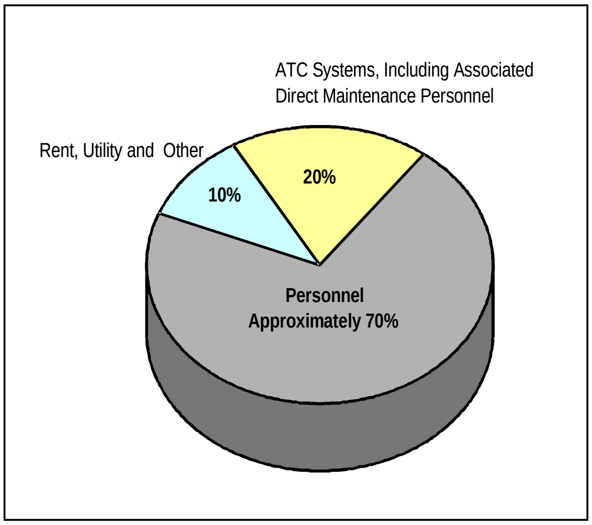

Figure 13-5. Estimated OPS Costs

13.3 Cost Estimate Methodology

Consistent with funding, a key goal of the NAS architecture is to modernize the NAS as quickly as possible to achieve Free Flight. In the architecture, investments are planned for new technology to implement Free Flight capabilities. Aging facilities and equipment are replaced in a time-phased manner. Capital investment is promoted to avoid escalating maintenance costs.

Most systems in the architecture are life-cycle funded. Life-cycle cost estimates include research and development; procurement; installation; operations; associated personnel costs; and technology updates and other system upgrades. The timing of funding for new systems and upgrades to existing systems is based on the estimated life cycles of existing systems and on the estimated refresh cycle of the associated replacement systems.

Some individual projects or investment areas (e.g., traffic flow management and communications) may show spikes of funding in some years. These numbers can be smoothed by using multi-year funding. As the budgeting process is completed, the estimates are revised to stabilize the yearly funding requirements.

Cost estimates are based on a variety of sources, including:

- Engineering judgment
- Industry estimates
- Investment analyses
- Cost-benefit analyses (CBAs)
- Life-cycle cost estimates prepared to support mission analyses
- April 1997 Future Telecommunications Book for communications OPS costs
- Cost Performance System (COPS) and the Workload Information System (WIS) for OPS costs
- F&E funding baselines as of June 1998
- Software Life Cycle Model (SLIM) estimates.

These sources were used as departure points for cost analyses to estimate life-cycle R,E&D, F&E, and OPS funding from 1998 through 2015. If a project changes significantly or if a new project is created, estimates will be derived using the best data and estimating tools available.

Estimates for programs that have been included in the current FAA financial baseline are expected to be at least 80 percent accurate. Estimates for new programs without approved baselines are less accurate. In other words, for programs without approved baselines, the actual costs will be lower than the estimate about half the time and higher than the estimate about half the time.

13.4 Watch Items

The ability to meet FAA funding projections.

13.5 Summary

The NAS Architecture Version 4.0 was developed to stay within the FAA's January 1998 funding projections. This modernization plan has identified all necessary funding needs for R,E&D, F&E, and OPS from 1998 through 2015. NAS modernization costs include training, procedures development, regulation changes, and certification requirements. The primary cost is for air traffic management services, which includes improvements in safety, capacity, security, and environment. AIP funding is not included in the architecture cost profiles; however, user avionics costs are included. Cost estimates are based on recognized industry practices.

PART III

NAS ARCHITECTURE DESCRIPTION

PART III

14 PART III NAS ARCHITECTURE DESCRIPTION OVERVIEW

Sections 15 through 32 discuss the NAS functional areas. Figure 14-1 illustrates the sequence of these functional areas by section number. Each section covers the following topics for each functional area:

- Overview
- Evolution
- Summary of Capabilities
- Human Factors
- Transition
- Costs
- Watch Items.

Figure 14-2 depicts the evolutionary steps of each major functional area by calendar year and shows the relationship of the steps to overall phases of NAS modernization. No effort was made to synchronize the dates of the steps across the domains. The steps occur when appropriate for each domain, given the program and implementation schedules involved.

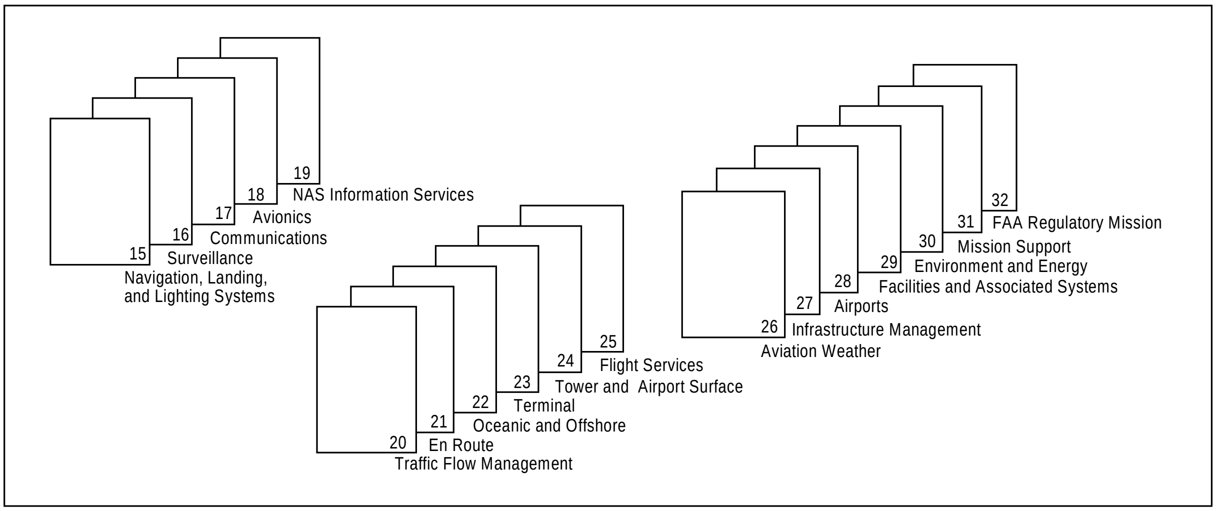

Figure 14-1. Roadmap of Functional Areas

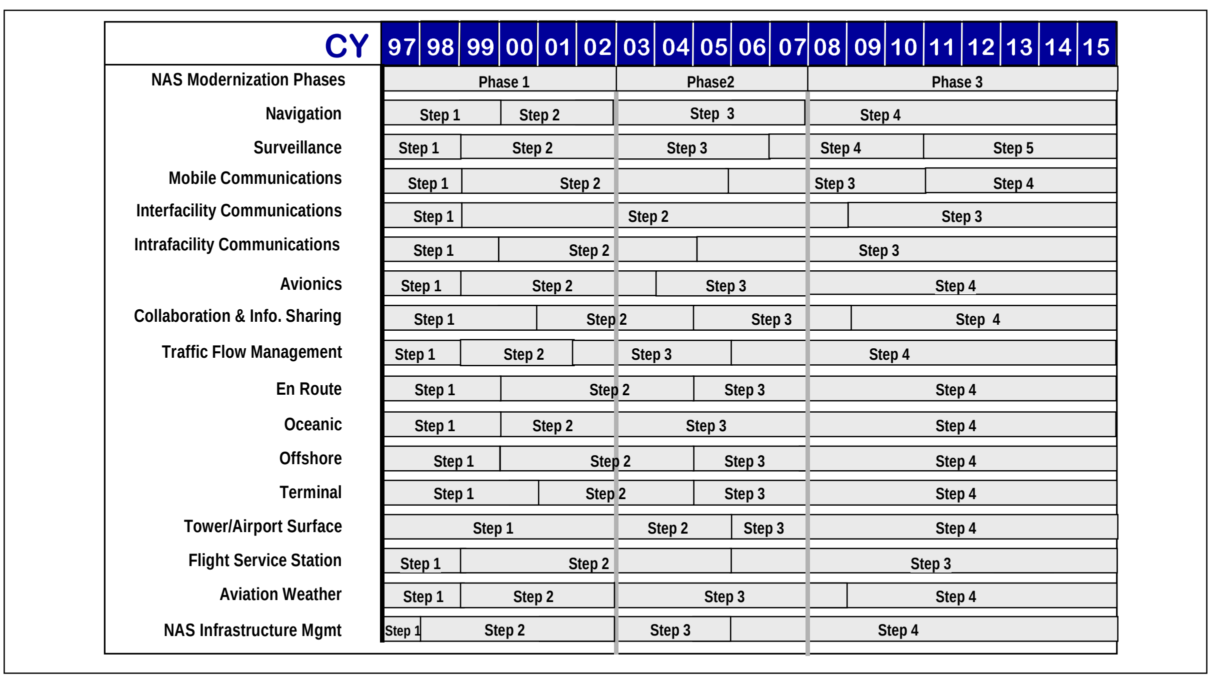

Figure 14-2. Functional Area Architectural Steps

15 NAVIGATION, LANDING, AND LIGHTING SYSTEMS

The FAA, the Department of Defense (DOD), and nonfederal agencies operate more than 4,300 ground-based electronic navigational aides (Navaids[1]) that broadcast navigation signals within a limited area. This network of Navaids enables users with suitable avionics to navigate en route and safely fly nonprecision (course guidance only) and precision approaches (course and glide path guidance) in most meteorological conditions.

The FAA also provides a variety of approach lighting systems that enhance pilot transition from instrument reference to visual reference for landing. Operational requirements, including the specific approach to be flown, dictate the types and configuration of the approach lighting system for a particular runway. Approach lighting systems enable Category (CAT) I precision instrument approaches to be flown to one-quarter-mile lower visibility minimums.

The navigation and landing system will evolve from ground-based Navaids to a satellite-based system that will consist of the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS) and the Local Area Augmentation System (LAAS). The satellite-based system will meet the demand for additional navigation and landing capabilities and improve safety while avoiding the cost of replacing, expanding, and maintaining many of today's ground-based Navaids.

The satellite-based navigation system will provide the basis for NAS-wide direct routing, provide guidance signals for precision approaches to most runway ends in the NAS, and reduce the variety of navigation avionics required aboard aircraft. Operational efficiency and safety will be improved by adding more than 4,200 precision approaches (and an additional 4,200 nonprecision approaches) at many airports lacking such capabilities today (see Section 28, Airports).

In order to take advantage of the opportunity the new capabilities offer to significantly increase capacity and to meet FAA forecasts for increased traffic, severely congested airports may require additional airport development (in terms of both clearance categories and pavement). Aviation system users and airports at low-capacity locations who want to take advantage of new opportunities may incur additional airport development costs.

DOD plans to replace the current GPS satellite constellation beginning in 2005. The new satellites will feature an additional frequency (i.e., a second frequency) to improve performance for civil use.

After sufficient time to allow for installation of satellite-based avionics and sufficient experience with WAAS and LAAS operations, a phase-down of ground-based navigation systems will begin. The phase-down is expected to begin in 2005. The exact timetable and extent of Navaid decommissioning will depend on the performance of the satellite-based systems, international agreements, and user acceptance.

Congress has directed a slowdown in WAAS until technical and programmatic uncertainties are resolved. Initial operating capability (IOC) for WAAS is expected to begin in 2000. IOC is expected to provide en route navigation and nonprecision and precision approach capability with some operational restrictions. Incremental improvements after IOC will enable pilots to use GPS/WAAS avionics for all phases of flight during instrument meteorological conditions.

There may be a need for a limited number of additional instrument landing systems (ILSs) to support new runways at capacity-constrained airports. These ILSs would be installed on an as-needed basis during the transition. Because GPS/WAAS is expected to provide service equivalent to a CAT I ILS, emphasis would be in supporting CAT II and III[2] requirements.

During phase-down, the reduced network of ground-based facilities (very high frequency

1. A Navaid is any visual or electronic device, airborne or on the surface, that provides point-to-point guidance information or position data to aircraft in flight, page 299, 1995 Airman's Information Manual/Federal Aviation Regulations (AIM/FAR).
2. Lowest authorized ILS minima are: CAT I, 200-foot decision height and 1,800 to 2,400-foot runway visual range (RVR); CAT II, 100-foot decision height and 1,200-foot RVR; CAT IIIa, no decision height and 700-foot RVR; CAT IIIb, no decision height and 300-foot RVR (Reference: FAA Order 8400.10 U.S. Standard for Terminal Instrument Procedures).

PART III

(VHF) omnidirectional range/distance measuring equipment (VOR/DME), nondirectional beacons (NDBs), tactical air navigation (TACAN), or ILSs)) will enable users who are not equipped with satellite-based avionics to continue to fly in the NAS. In some areas, these aircraft will need to follow more circuitous routes than aircraft with satellite-based avionics. In the event of an unexpected localized loss of satellite-based services, aircraft equipped exclusively with satellite-based avionics in airspace with radar services will be vectored to visual conditions, to areas where Navaid reception provides backup, or to regions unaffected by the loss of the satellite navigation (SAT NAV) signal.[3]

Studies are underway to: (1) determine how many ground-based facilities should remain in service to provide a temporary/permanent redundant navigational capability, and (2) determine whether GPS/WAAS can be the only navigation capability carried aboard an aircraft and provided by FAA. The NAS Architecture will be revised in accordance with the study results.

15.1 Navigation and Landing Architecture Evolution

The following four steps present the evolution from ground-based to satellite-based Navaids:

- Step 1: Navigation and Landing Architecture (Current–1999)
- Step 2: Implementation of WAAS (2000–2002)
- Step 3: Completion of WAAS; Implementation of LAAS; Start Phase-Down of Ground-Based Navaids (2003–2007)
- Step 4: Completion of Phase-Down of Ground-Based Navaids (2008–2015).

15.1.1 Navigation and Landing Architecture Evolution—Step 1 (Current–1999)

Figure 15-1 illustrates the current navigation architecture. The VOR/DME network provides users with a primary means of navigation for en route flight and nonprecision approaches. The network consists of more than 1,000 VOR, VOR/DME, or VORTAC (VOR co-located with TACAN) facilities. The DOD operates an additional 30 such facilities at terminal locations.

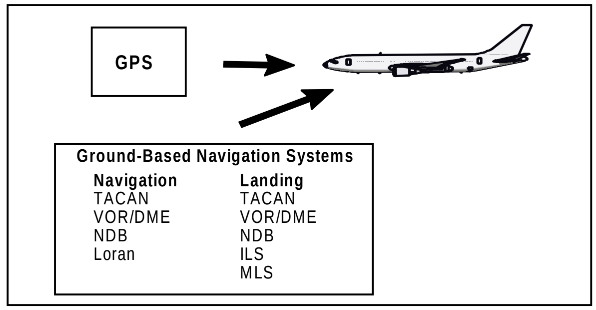

Figure 15-1. Current Navigation Architecture

To supplement the VOR/DME network, the FAA operates more than 700 NDBs, and the DOD about 200 NDBs. NDBs are used as compass locators in conjunction with some ILSs and for nonprecision approaches at low-traffic airports without convenient VOR approaches. NDBs are also used for en route operations in some remote areas and for transitioning from oceanic to domestic en route airspace.

The FAA operates more than 600 TACAN systems to provide air navigation for most military aircraft. DOD also operates more than 150 TACANs. The U.S. Coast Guard operates the Loran-C system, which can be used for en route navigation in the NAS, provided another system (VOR/DME, NDB, or TACAN) is carried onboard. Current Loran-C avionics do not support instrument approach operations.

The FAA and DOD operate two types of precision approach Navaids: ILS and a limited number of microwave landing systems (MLS). The FAA operates about 1,000 ILSs and 26 MLSs. DOD operates 180 ILSs and precision approach radars.

DOD operates the GPS satellite constellation. GPS provides worldwide, all-weather, 3-dimensional position, velocity, and time data to a variety of civilian and military users. GPS is approved for en route navigation and nonprecision approaches, provided that another system (VOR/DME, NDB, or TACAN) is carried onboard. Certain GPS receivers are approved for navigation in oceanic and remote airspace; no other navigation systems are required onboard.

3. While some surveillance systems will evolve to make use of the GPS signals, surveillance radars will not be dependent on GPS (see Section 16, Surveillance).

The FAA operates and maintains approximately 1,000 approach lighting systems. They consist of a configuration of lights starting at the landing threshold and extending into the approach area. Some systems include sequenced flashing lights that appear to the pilot as a ball of light traveling toward the runway at high speed.

A variety of approach lighting system configurations exist. The most common are the medium-intensity approach lighting systems with runway alignment indicator lights (MALSR) to support CAT I precision approaches and the high-intensity approach lighting system with sequenced flashing lights (ALSF-2) to support CAT II and CAT III precision approaches.

The FAA also operates and maintains approximately 1,700 visual glide slope indicators. These consist of 1,350 visual approach slope indicators (VASIs) and 350 precision approach path indicators (PAPIs). Visual glide slope indicators provide visual reference to pilots as they approach the runway for landing. Currently, the FAA is replacing the VASIs with PAPIs because PAPIs conform to International Civil Aviation Organization (ICAO) international standards while VASIs do not.

Depending on their operational needs and financial constraints, users choose to equip their aircraft with a variety of avionics for navigating in the NAS. These include:

- *GPS:* Provides navigation in oceanic and remote airspace. It can be used for en route navigation and nonprecision approaches in domestic airspace, provided another system (VOR/DME, NDB, or TACAN) is carried onboard.
- *VOR/DME:* Provides navigation guidance for en route navigation and nonprecision approaches (TACAN for DOD).
- *ILS:* Provides navigation guidance for CAT I/II/III precision approaches.
- *Automatic Direction Finder (ADF):* Provides direction to an NDB ground transmitter. One use is for a nonprecision instrument approach, based on tracking to or from the beacon, without an electronic glideslope.
- *Loran-C:* Can be used for en route navigation, provided another system (VOR/DME, NDB, or TACAN) is carried onboard. Current Loran-C avionics do not support instrument approach operations.
- *Inertial Systems:* Are self-contained systems used in many military and transport aircraft for oceanic and domestic en route navigation.
- *MLS:* Provides a limited number of CAT I precision approaches and some nonprecision instrument approach operations.

Nonfederal organizations (i.e., airport authorities, states, airline operators, etc.) fund and operate approximately 1,500 Navaids at locations that do not qualify for federal funding due to insufficient traffic. These organizations maintain and operate the Navaids, and the FAA inspects and verifies their safe operation under the nonfederal program. The nonfederal Navaids include approximately: 200 ILSs, 1,000 NDBs, 60 VORs, 100 DMEs, 10 MLSs, and 50 to 100 lighting aids of various types.

15.1.2 Navigation and Landing Architecture Evolution (Implementation of WAAS)—Step 2 (2000–2002)

The implementation of satellite navigation will help the NAS to meet increasing aviation traffic and will allow a reduction in the number of ground-based Navaids. The GPS signal must be augmented to ensure accuracy, integrity, continuity, and availability (see Figure 15-2). WAAS will augment the GPS signal for en route and terminal navigation and instrument approaches. GPS, augmented by WAAS, will provide instrument approaches to CAT I minima at most runway ends in the NAS (where obstacle clearance, runway,

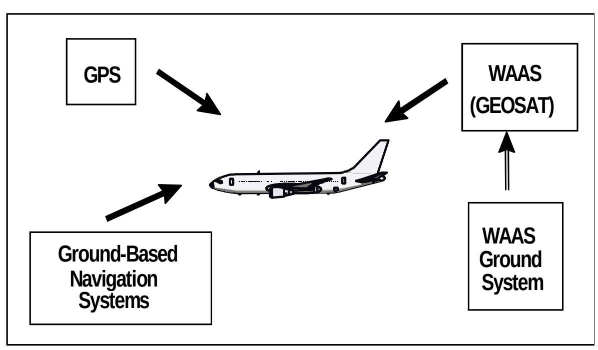

Figure 15-2. GPS Augmented by WAAS

PART III

lighting, and signage requirements are met). Because WAAS can provide precision approaches to new runways, to CAT I minima if required, the need for new ILS CAT I approach equipment will be eliminated. In addition to added instrument approaches, users will benefit from increased area navigation and more direct routing.

WAAS consists of master stations and precisely surveyed reference stations interconnected by a terrestrial communications infrastructure. Communications from the ground master stations are broadcast to aircraft via WAAS geostationary satellites (see Figure 15-3).

To improve GPS accuracy, WAAS geostationary satellites (GEOSATs) will broadcast differential corrections for ionospheric delay, satellite position, and satellite clock errors. The reference stations monitor the GPS and WAAS signals to ensure system integrity and report any anomalies to the master station. GEOSATs broadcast status to the aircraft avionics. Availability is improved because WAAS geostationary satellites appear to the avionics as additional GPS satellites.

WAAS will be implemented in phases, with operational capability improving at each phase. The initial phase, which consists of 25 reference stations, 2 master stations, and GEOSAT uplink stations, has been installed. It is in the process of being networked and tested to provide an initial operating capability (IOC) for flight operations in 2000. The IOC will provide signals for domestic en route navigation and nonprecision and precision instrument approaches with operational restrictions within a limited WAAS coverage area.

During this phase, WAAS-equipped aircraft will be able to fly instrument flight rules (IFR) without having other navigation avionics aboard (e.g., VOR/DME or NDB). However, procedural or operational restrictions may affect the availability of GPS/WAAS approaches in some areas of the country. Flights in these areas will need to rely on existing procedures and VOR/DME or NDB.

The initial phase of WAAS will provide CAT I precision approach capability within a limited coverage area. However, the precision approach minima initially authorized may be somewhat higher than current CAT I ILS minima while both the FAA and aircraft operators gain experience. Procedural or operational restrictions may affect approach availability.

Decisions on approach minima will need to be made at some locations where ½-mile visibility is not necessary, thus avoiding the high cost of instrument approach lighting systems. During this initial phase, pilots who need to plan for an IFR alternate airport may need to rely on visual approach procedures or on Navaids, such as ILS, VOR/DME, or NDB, similar to operations today. The initial WAAS precision approach coverage area will be limited, depending on the location of WAAS reference stations and the coverage of WAAS satellites. The coverage volume will gradually increase as data are collected to substantiate GPS/WAAS ionospheric performance.

An interim phase will provide additional master and reference stations to improve WAAS coverage, performance, and real-time availability. Automated notice to airmen (NOTAM) service with predictive capabilities will become available.

Instrument approach procedures based on GPS/WAAS will be published by WAAS IOC. Subsequently, 500 procedures will be published each year until requirements are met. In addition, 500 GPS nonprecision approach procedures will be developed annually.

15.1.3 Navigation and Landing Architecture Evolution (Completion of WAAS, Implementation of LAAS, Start Phase-Down of Ground-Based Navaids)—Step 3 (2003–2007)

In its final phase, WAAS will achieve full operating capability (FOC) by the addition of ground monitoring and control stations and geosatellites. Hardware installed earlier in the program will be upgraded. WAAS will then provide performance equivalent to ILS CAT I with a level of service that is sufficient to replace existing VOR/DME and NDB facilities and most CAT I ILS facilities. Also at FOC, the interim procedural and operational restrictions imposed at IOC will be removed.

To provide additional precision approaches, LAAS will be installed to augment GPS in this step. LAAS will augment GPS at a planned 112 airports in the NAS to provide CAT II/III precision approaches (see Figure 15-4).

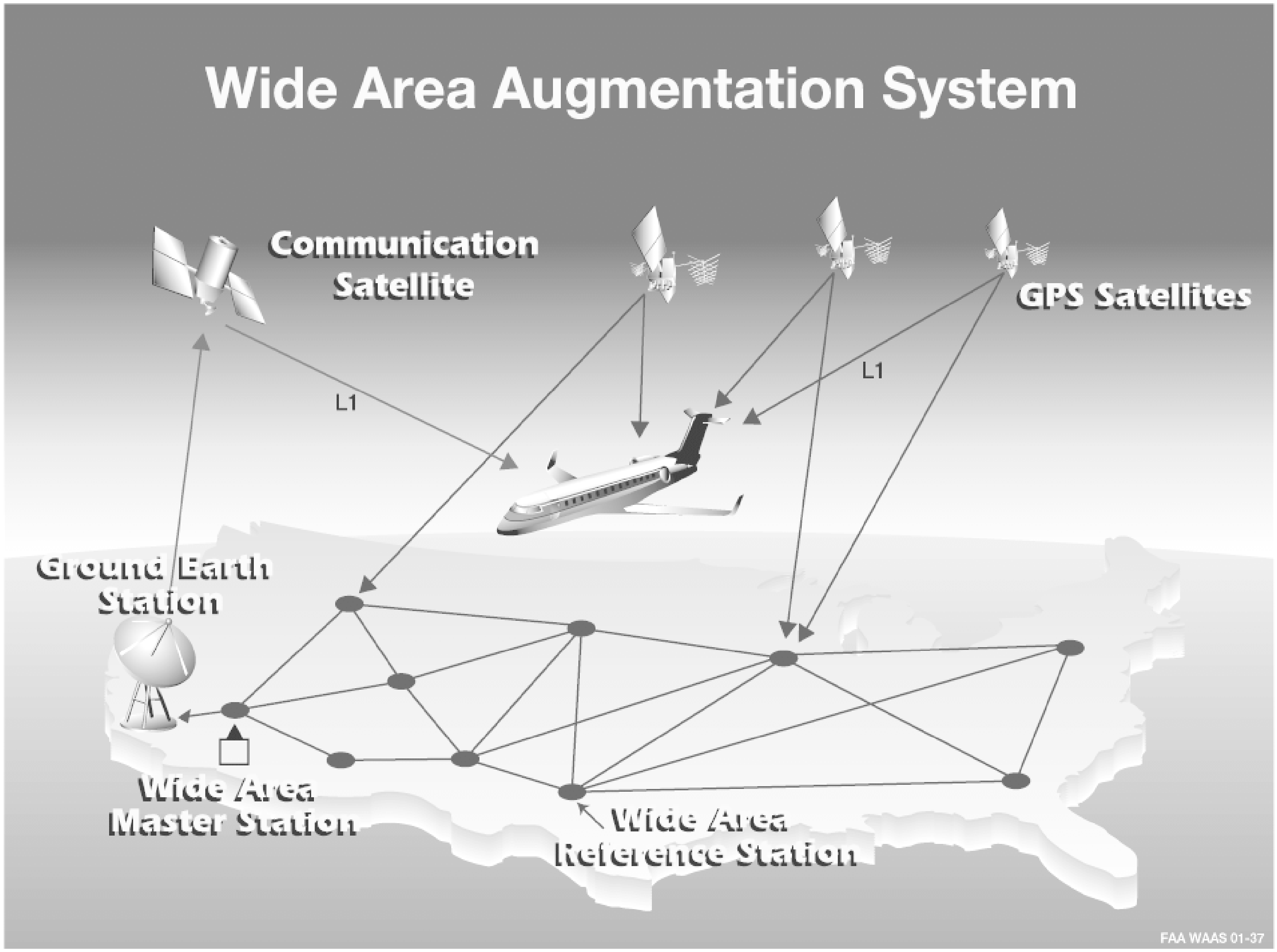

Figure 15-3. Wide Area Augmentation System

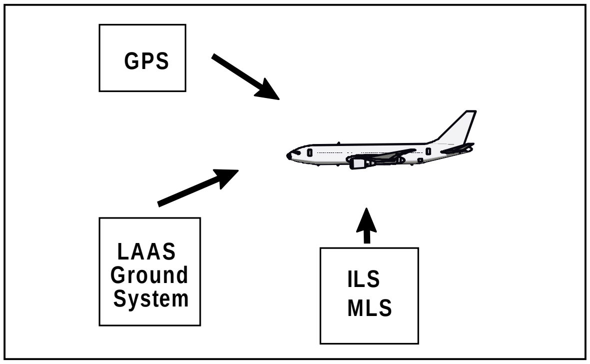

Figure 15-4. GPS Augmented by LAAS

LAAS will also provide CAT I precision approaches at a planned 31 airports that are either outside of WAAS coverage (17) or have high activity that requires a higher availability than WAAS can support (14). LAAS capability does not require WAAS, and its implementation schedule is independent of the WAAS program. The LAAS architecture is shown in Figure 15-5.

Suitable approach lighting systems will be installed to support additional precision instrument approach procedures enabled by LAAS.

A LAAS installation is anticipated to consist of a precisely surveyed ground station with multiple GPS receivers, a VHF link, and one or more pseudolites[4] to increase availability. The LAAS ground station will calculate differential accuracy corrections based on the station's location and on measurements taken from each GPS satellite. It will then broadcast the corrections on VHF radionavigation frequencies, together with an integrity message, to aircraft within a radius of 20 to 30 nmi from the airport. LAAS is expected to be significantly more affordable to install, operate, and maintain than ILS. One LAAS will allow CAT II/III precision approaches at all runway ends at an airport, topology and lighting equipment permitting. This is a savings compared to ILS technology, which requires each runway end to have an ILS.

LAAS is expected to support ground operations such as runway incursion avoidance and airport surface navigation and surveillance. For additional information about how LAAS will be used in the NAS, refer to Section 16, Surveillance; Section 18, Avionics; Section 23, Terminal; and Section 24, Tower and Airport Surface.

The FAA's plans for the transition to SAT NAV technology and for the phaseout of ground-based Navaids will be periodically reevaluated. An FAA-funded risk assessment study is being conducted to determine whether satellite navigation technology can serve as an only means of radionavigation in the NAS. Assessment results are expected in early 1999. If it is determined that GPS/WAAS/LAAS cannot satisfy the performance requirements to be the only navigation system installed in an aircraft or provided by the FAA, then it may be necessary to maintain a reduced network of ground-based Navaids beyond 2010 to support satellite navigation.

As soon as circumstances permit, the FAA plans to begin reducing the number of ground-based Navaids in a two-step phase-down. Criteria for identifying the Navaids to be shut down will be published well ahead of the first step.

Prior to starting the first step of phase-down, the FAA, in conjunction with users, expects to determine whether the phase-down schedule should be adjusted. Preliminary analysis indicates that approximately 350 VORs and 300 ILSs would be shut down in the first step, leaving sufficient ground-based Navaids to enable users who are not equipped with satellite-based avionics to continue to fly in the NAS.

15.1.4 Navigation and Landing Architecture Evolution (Completion of the Phase-Down of Ground-Based Navaids)—Step 4 (2008–2015)

Completion of the first step of the ground Navaid phase-down is expected in 2008. A second step, slated for 2009 to 2010, would shut down approximately 100 VORs, 250 ILSs, and 470 NDBs.

The remaining Navaids (approximately 600 VOR/DMEs, 500 ILSs, and 280 NDBs) would be sufficient to support en route navigation and instrument operations at the busier airports in the NAS (about 2,400) should there be a disruption in GPS/WAAS service.

4. A pseudolite is a ground-based transmitter of GPS-like signals that are used for ranging. The number and placement of pseudolites will depend on the topology of each site.

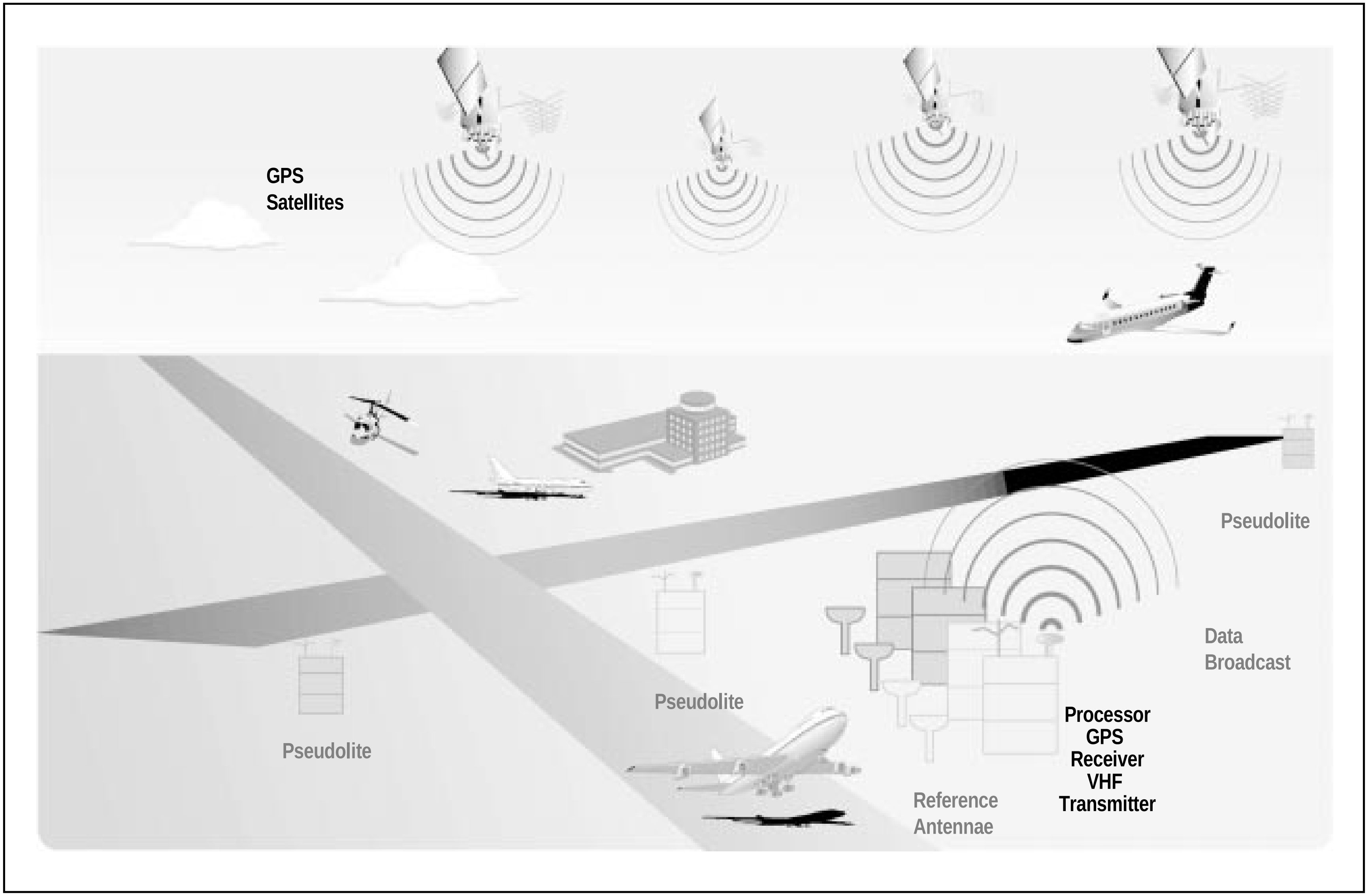

Figure 15-5. LAAS Architecture Overview

Because precision landing services will eventually depend primarily on the use of GPS signals augmented by WAAS and LAAS differential correction signals, it is clear that these systems need to be protected from harmful interference. The FAA[5] is currently working with DOD to develop safety and system security countermeasures for satellite-based navigation and landing systems to prevent or mitigate interference such as jamming. Integrity of the satellite-based system will be assured prior to phasing out ground-based Navaids. New GPS satellites with a second civil frequency capability will be launched during this period to replace all the current GPS satellites. The addition of the second civil frequency will mitigate the effects of unintentional jamming and could also provide increased accuracy by means of the direct measurement of ionospheric delay by aircraft dual-frequency avionics.

Ground-based systems are expensive to procure, install, and maintain. Current NAS planning includes sufficient funding to maintain the Navaid infrastructure in accordance with near-term aviation growth and with the navigation and landing architecture described herein (i.e., with a Navaid phase-down).

However, if users do not convert to GPS-based avionics, and if plans to phase out ground-based Navaids are not realized, then Navaids reaching the end of their service life will need to be replaced.

Currently, it costs the FAA $170M annually to operate the ground-based system. Replacing the ground-based systems would require an estimated $2.61B investment.[6] Additionally, if users do not convert to GPS-based avionics, more ground-based Navaids will be needed over time to support aviation growth. For example, more than 200 airport authorities have requested, and are eligible for, new ILS installations.[7]

Substantial investment would be required to install or replace Navaids designed to support a 1950's operational concept. Such an investment would not improve NAS operations, whereas WAAS and LAAS support direct routes and enable more flexible use of airspace.

After satellite-based systems are deployed and certified, and before other Navaid systems can be phased out[8] (see Figure 15-6), the following three essential prerequisites must be met:

System Performance. New technology must meet service requirements. This will be determined through analyses, flight tests, and operational experience.

Operational/Economic Benefits. There must be sufficient operational and economic incentive before users will invest in satellite-compatible avionics. Economic benefits include using a WAAS or a WAAS/LAAS receiver in lieu of multiple avionics, fuel savings from user-preferred routes, and direct routes in high-density areas. Operational benefits include instrument approaches at new airports and runway ends and enhanced efficiency because of additional approaches. GPS with WAAS augmentation can provide vertical guidance for all future instrument approach procedures—greatly increasing flight safety. In the past, pilots readily accepted and began using satellite-based navigation soon after it was certified as a supplemental means of navigation. Additional user implications and costs are described in Section 18, Avionics.

Transition Period. The transition period begins with the initial operational availability of GPS/

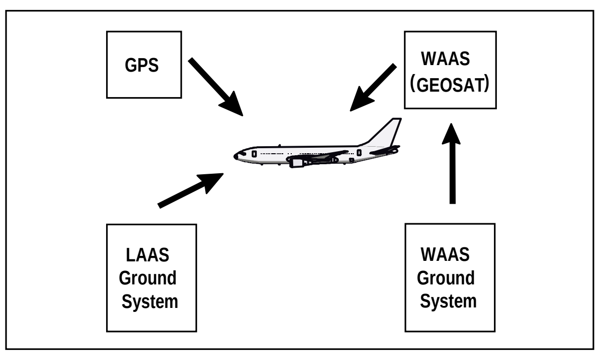

Figure 15-6. Ground-Based Navaids Phased Out

5. The FAA integrated product team and the NAS Information Security Program.
6. FAA cost estimate.
7. Reference: Mission Need Statement 120, Establishment of ILS and Associated Aids, paragraph 9(b)(2), 2 Feb 1993.
8. Under current law, ground-based Navaids can be transferred to nonfederal sponsors who can continue to operate them. However, the FAA needs to recover valuable VHF spectrum to use for other safety-critical services.

WAAS and associated avionics in 2000. Users must have time to recoup their investment in current avionics, and the FAA must have time to develop and publish instrument approach procedures for use with the new technology. A reasonable compromise must be reached between the FAA's desire for a rapid transition and the aircraft operator's desire to use current equipment as long as possible.

15.2 Summary of Capabilities

The existing ground-based navigation and landing capabilities will evolve to a satellite-based system using GPS and related augmentation systems (see Figure 15-7). GPS/WAAS will become the primary means for en route and terminal navigation and will provide CAT I approach capability to airports. GPS/LAAS will provide CAT II and III precision approaches to selected airports. LAAS will also provide CAT I approaches to airports outside WAAS coverage and to a few high-activity airports. As WAAS/LAAS coverage extends throughout the NAS, the ground-based navigation and landing systems will be phased down, leaving sufficient Navaids to support principal air routes and instrument approaches at high-activity airports, should there be a GPS/WAAS service outage.

In its initial phase, WAAS will provide a functional verification system for developing test and evaluation procedures and conducting WAAS system-level testing and operational testing. During this time, GPS can be used for en route navigation and precision approaches in a limited coverage area; however, some additional procedural or operational restrictions may be necessary. Subsequent phases will incorporate additional ground hardware, software upgrades, geosatellites, and improved operational control until WAAS FOC is achieved. WAAS will then satisfy requirements for using GPS for departure, en route, and terminal area navigation and for CAT I precision approaches. The operational and procedural restrictions initially imposed will not be necessary.

LAAS is expected to also provide the all-weather capability needed for precise airport surface navigation. A single LAAS will provide CAT II/III precision approach capability to all runways at an airport. LAAS capability and deployment is independent of WAAS.

15.3 Human Factors

Until now, only a relatively few users, equipped with flight management computer systems or Loran-C, had a flexible, point-to-point navigational capability. In the immediate future, however, any aircraft equipped with GPS or WAAS avionics will have the capability to navigate directly between any two points, independent of Navaids or traditional published routes.

Pilots seeking to take full advantage of this direct routing capability pose a significant challenge to the air traffic control (ATC) system and to controllers, who are tasked with ensuring safe separation between aircraft while facilitating efficient traffic flow. New procedures, automation tools, and training will be necessary to help controllers

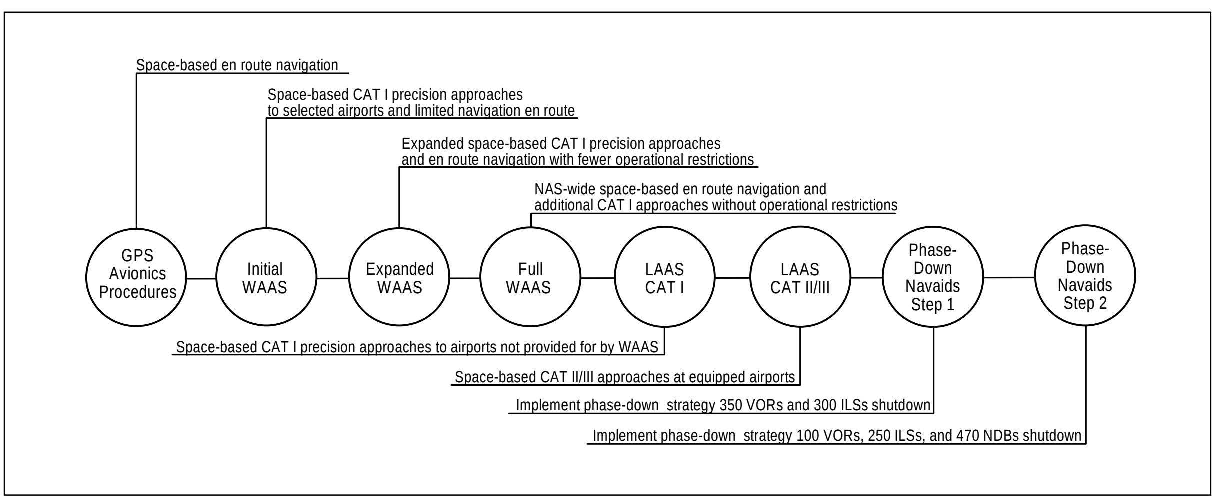

Figure 15-7. Navigation and Landing Capabilities Summary

and pilots manage these capabilities safely and efficiently.

New cockpit displays, including moving maps and cockpit display of traffic information (CDTI), are either available or in development. Traditional fixes used by controllers and pilots will be replaced by pilot-defined waypoints. The georeferences for navigation and surveillance will change. Additionally, new GPS-based instrument approach procedures are being developed. The Safe Flight 21 Program is intended to provide the means for developing and/or testing the equipment features and the pilot and controller procedures needed to realize the full benefits of GPS/WAAS and LAAS.

15.4 Transition

The navigation and landing transition schedule is shown in Figure 15-8. Specific activities associated with the navigation and landing architecture are:

- Safe Flight 21 Program demonstration of prototype LAAS at demonstration sites
- GPS/WAAS backup analysis
- WAAS deployment (IOC/FOC)
- LAAS deployment
- Ground-based Navaids phase-down strategy.

15.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for navigation, landing, and lighting systems architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 15-9.

15.6 Watch Items

The evolution of the navigation architecture depends on policy decisions, regulations, equipment certification, standards development, and performance factors. These include:

- Availability of GEOSATs (Additional satellites are needed for WAAS to achieve its full operational capability. A study will evaluate the options available for providing the additional satellites. Funding to lease the additional satellite capability is programmed to begin in FY02 or 03.)
- Studies on redundant Navaids (The FAA is studying what redundant navigational capability may be required in the event of a GPS outage.)
- Certified, affordable avionics

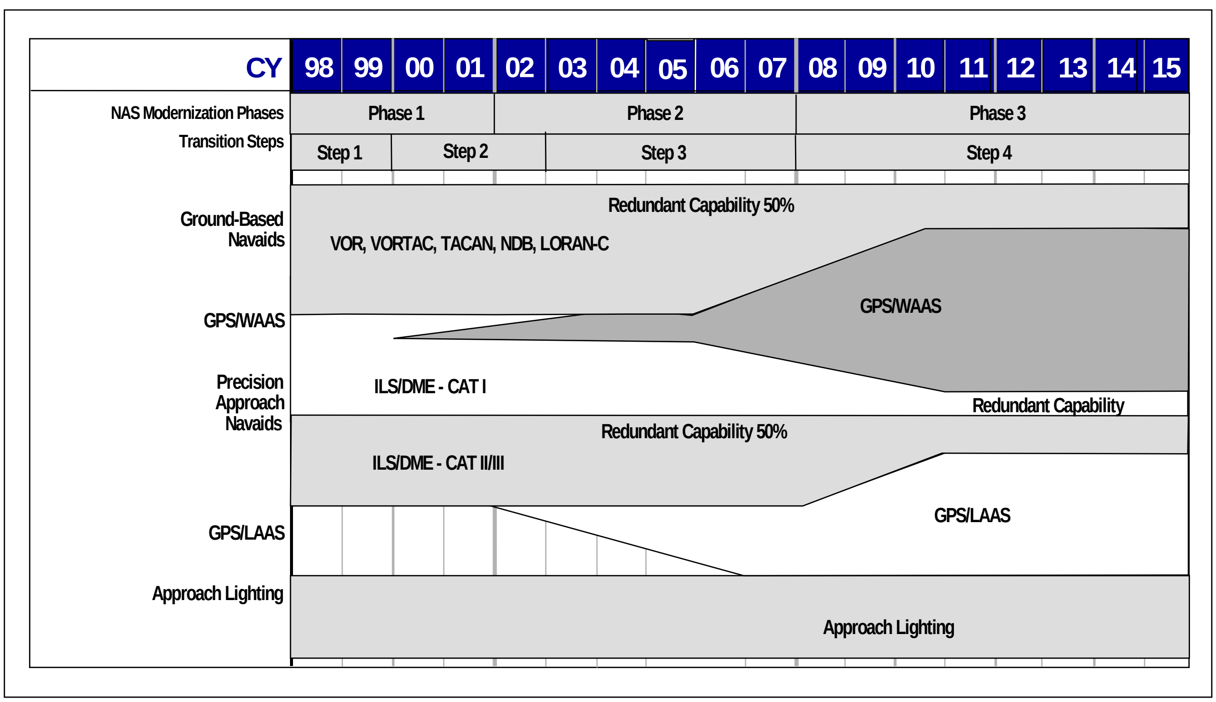

Figure 15-8. Navigation and Landing Transition

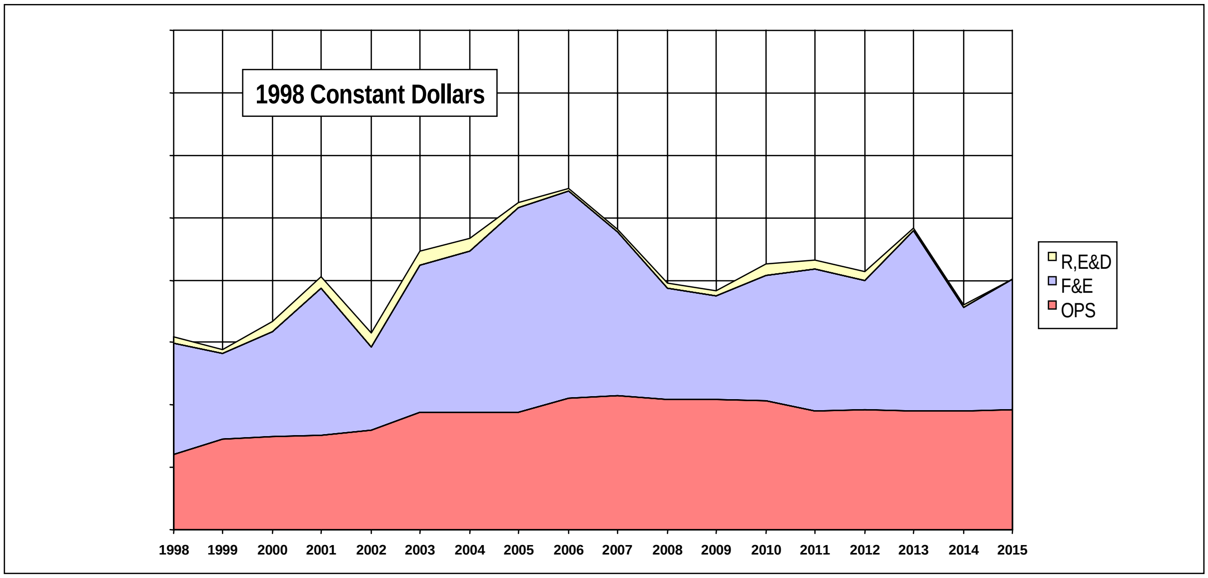

Figure 15-9. Estimated Navigation Costs

- Policies on carrying redundant equipage
- Programmatic issues
  - WAAS performance
  - LAAS/WAAS schedule
  - Development of LAAS standards
  - Second civil frequency
- Policy issues:
  - Notice of proposed rulemaking for airspace minimum avionics equipage and required navigation performance
  - Reuse of frequency spectrum presently dedicated to navigation for other aeronautical services
  - Continuation or shutdown of nonfederal Navaids
  - Rate and willingness of users to equip with WAAS/LAAS avionics
- International interoperability:
  - International agreements and standards for satellite-based systems to ensure global interoperability[9]
  - Operational procedures.

PART III

9. The United States leads or actively participates on several ICAO Air Navigation Commission (ANC) panels. Panel members develop international standards, which are approved by the Council, ICAO's governing body. It is essential to NAS architecture development to fully incorporate these international standards. Within the navigation area, recent standardizing efforts include work on: airspace planning methodology for determining separation minima by the Review of the General Concept of Separation Panel (RGCSP); standards and recommended practices (SARPs) development by the All Weather Operations Panel (AWOP); and long-term requirements and SARPs developed by the Global Navigation Satellite System Panel (GNSSP).

16 SURVEILLANCE

Following are definitions of the terms used in the surveillance architecture:

Independent Surveillance: The use of primary radar to independently detect and determine the range and azimuth (2-dimensional position) of aircraft by means of reflected radar energy. Airport surface detection equipment (ASDE) primary radars are used to determine the position of aircraft and vehicles operating on airport taxiways and runways. Primary radar surveillance is *independent* because aircraft or ground vehicles need not be equipped with any enabling avionics to be detected.

Cooperative Surveillance: The use of secondary surveillance radar (SSR) to determine the position, assigned beacon code (4,096 codes are currently available), and in most cases, the barometric altitude of an airborne aircraft by interrogation of a transponder onboard the aircraft. Because the aircraft must be equipped with a transponder, SSR technology is deemed to provide *cooperative* surveillance. Mode-3/A transponders reply with only the assigned code. Mode-3/C transponders (the most common type) reply with both assigned code and altitude. Mode-Select (Mode-S) transponders reply with assigned code and barometric altitude to all SSR interrogators and also include a discrete, permanently assigned address when replying to Mode-S interrogators. The Mode-S system also permits additional data to be exchanged between aircraft and Mode-S radars.

Automatic Dependent Surveillance:

- *Automatic Dependent Surveillance Broadcast (ADS-B):* The function on an aircraft or surface vehicle that broadcasts position, altitude, vector, and other information for use by other aircraft, vehicles, and ground facilities.
- *Automatic Dependent Surveillance (ADS):* The use of ADS-B information by ground facilities to perform surveillance of airborne aircraft and aircraft or vehicles operating on the airport surface. This technology is deemed to provide *dependent* surveillance because it relies totally on each aircraft to determine its position (by means of the onboard navigation system) and report that position (and other data) via ADS-A or ADS-B communications equipment.
- *Automatic Dependent Surveillance Addressable (ADS-A):* A different form of ADS, designed to support oceanic aeronautical operations, based on one-to-one communications between aircraft providing ADS information and a ground facility requiring receipt of ADS reports. The term “ADS-A,” as used here is equivalent to “ADS” as discussed in International Civil Aviation Organization (ICAO) documentation.

Overview

The concept of operations (CONOPS) calls for surveillance of all controlled aircraft in the domestic airspace, using ADS and radar systems. ADS will be based on aircraft latitude/longitude position and velocity reports from the aircraft’s navigation system, barometric altitude, as well as short-term intent information (next way points). The CONOPS emphasizes the importance of ADS for both air-air and ground-based surveillance and extending instrument flight rules (IFR) separation services to nonradar areas of domestic airspace. The future cockpit applications for ADS-B include:

- Pilot situational awareness
- Separation assurance
- Limited shared responsibility for separation
- Safer airport surface operations in reduced visibility conditions.

The surveillance architecture will support Free Flight, provide increased surveillance coverage, improve safety, and increase airspace capacity. Changes in surveillance are designed to open airspace, allow for more direct routings, and increase NAS flexibility to meet growing demand.

The current domestic surveillance system consists of primary and SSRs that are used to detect aircraft and determine their position and identity. Air traffic control (ATC) automation systems process the radar data for display to air traffic controllers. Controllers use these data to separate aircraft flying under IFR from other aircraft, obstacles, terrain, and special use airspace and to provide weather advisory services. Weather detection functions provided by today's radar surveillance systems are discussed in Section 26, Aviation Weather.

The NAS surveillance architecture will use primary radars with digital technology for terminal airspace, but primary radars will be phased out of en route airspace. SSRs with selective interrogation (SI) capability will be used in both en route and terminal airspace. The SI capability allows the ATC automation, when modified, to utilize the unique Mode-S transponder identification code permanently assigned to an aircraft; eliminates false data from the controller's display; and supports use of Mode-S data link to provide traffic information service (TIS) to the cockpit.

The Mode-S data link will also enable use of a future Ground-Initiated Communications Broadcast (GICB) message. The accuracy of the position and intent information received from the aircraft via the GICB message is expected to significantly improve target tracking and the performance of controller tools such as conflict alert, conflict probe, and the Final Approach Spacing Tool (FAST). The GICB will capture the aircraft's ADS-B information in concert with the beacon interrogation. This allows independent verification of position, supports separation between ADS-B aircraft and those not equipped (especially important during transition), and allows the FAA to use the SSR network as part of a larger network of ground listening stations.

If enough users equip with ADS-B avionics, ADS-B for air-air surveillance will be implemented in domestic and oceanic airspace. Pilots are expected to use ADS-B air-air surveillance for situational awareness. In oceanic airspace, ADS-B may be approved as a means for pilots to conduct in-trail climbs, descents, and passing maneuvers.

If enough users equip, compatible ADS ground systems, which leverage off of the avionics equipage, will be implemented in domestic airspace (see Figure 16-1). Due to the characteristics of ADS-B (frequent broadcast of position), ADS-B-based surveillance is expected to be the most accurate form of surveillance, potentially allowing minimum aircraft separation standards to be reduced. These surveillance improvements are expected to help expedite traffic flow in the NAS.

The CONOPS calls for implementing surveillance capability in oceanic airspace. In today's oceanic airspace environment, "procedural" separation between aircraft is managed by means of high frequency radio position reports provided verbally by pilots to controllers, indirectly through a third-party commercial communications provider. No means of direct oceanic surveillance is currently available. Consequently, the required lateral/longitudinal separation between aircraft in oceanic airspace is very conservative (between 60 and 80 nmi), and the capability to approve route and altitude changes is constrained.

ATC surveillance in oceanic airspace will be based on ADS-A reports to oceanic controllers via satellite communications (SATCOM), high frequency data link (HFDL), or other subnetworks. The reports, which are derived from Future Air Navigation System (FANS-1A) or aeronautical telecommunications network (ATN) avionics, include barometric altitude, latitude/longitude position, velocity, and short-term intent information (next way points). Ground equipment and automation will display the aircraft position and track to oceanic controllers, enabling current lateral/longitudinal separation standards to be reduced.

16.1 Surveillance Architecture Evolution

To ensure high availability of services in domestic airspace, the surveillance architecture provides at least two complementary means of surveillance. For example, if the aircraft navigational system associated with ADS-B malfunctions, beacon interrogation will continue to provide cooperative surveillance as a basis for separation. In oceanic airspace, surveillance will be provided by ADS-A communicated via SATCOM, HFDL, or other subnetworks.

Surveillance System Domains

Surveillance systems support four NAS domains: (1) en route, (2) oceanic, (3) terminal, and (4) tower/surface.

En Route Domain. A new SSR air traffic control beacon interrogator (ATCBI-6) with SI and the GICB feature will be installed at all ATCBI-4 and ATCBI-5 en route radar sites.

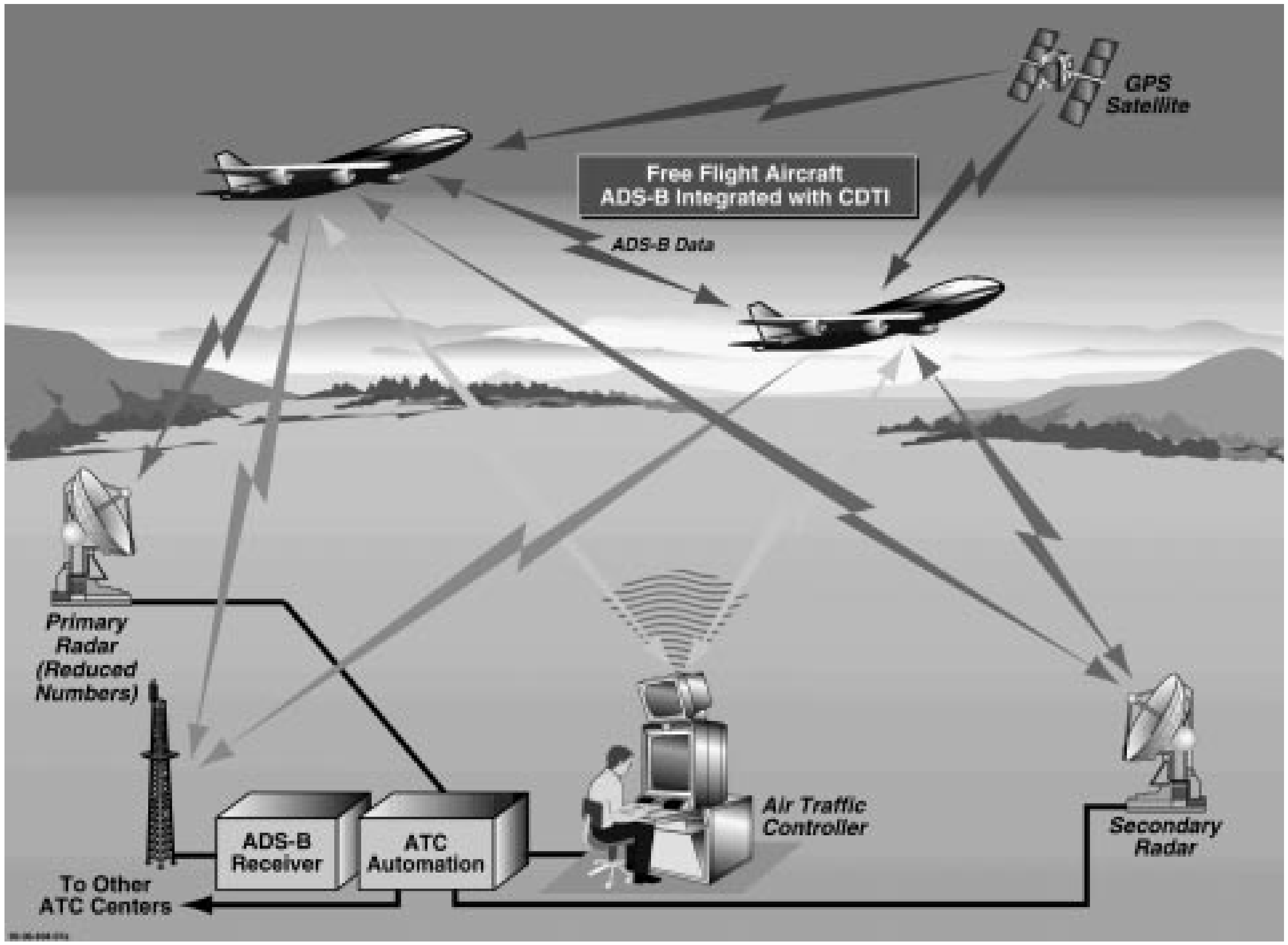

Figure 16-1. Proposed Surveillance System Architecture

The ATCBI-6 will work with Mode-3/A and 3/C transponders, enabling the ATC system to remain compatible with all users as they transition to ADS-B avionics. The Mode-S SSR will remain in service at 25 sites. They will be configured to provide TIS, a Mode-S data link service that provides automatic traffic advisories to properly equipped aircraft.

The SI capability of the Mode-S and ATCBI-6 radars will enable the air route traffic control centers (ARTCCs) to use Global Positioning System (GPS) data for surveillance via GICB. ADS capability will also be installed. The continued use of SSRs will enable the ATC system to maintain full service in domestic en route airspace whenever there is any difficulty with the ADS system. Continued use of SSRs also permits an extended transition period for general aviation (GA) in low-altitude airspace. Primary en route radars will be phased out of interior areas, except for those needed by the Department of Defense (DOD), or other agencies.

Oceanic Domain. ADS based on ADS-A will be implemented in oceanic airspace. SATCOM is emerging as the primary communications link for ADS-A and other oceanic communications, with HFDL likely to be used as an alternative source.

Terminal Domain. A new digital, combined primary/SSR system (airport surveillance radar (ASR)-11) will be deployed to complement the ASR-9/Mode-S system. The Mode-S will be configured to provide TIS. All ASR-11 integrated beacons will be upgraded to include SI and GICB capability. Terminal radar approach control (TRACON) facilities will begin to use ADS for surveillance. All three means of surveillance (primary radar, secondary radar, and ADS) will be retained in the terminal domain.

Tower/Airport Surface Domain. ASDE-3 will receive a service life extension. A new surface surveillance capability with conflict detection capability will be installed at additional airports. ADS capability for surface surveillance will also be installed. The accuracy of Wide Area Augmentation System (WAAS)- and Local Area Augmentation System (LAAS)-derived ADS-B (with LAAS taking precedence) is expected to enable the ADS system to support substantial airport surface operations in reduced visibility conditions. The airport surface ADS system will also feature a multi-lateration capability that uses aircraft transponder replies, triggered by the terminal SSR or local interrogators, to determine the identification and the position of non-ADS-B aircraft on the airport surface. Adding multi-lateration provides an alternate means of surveillance in absence of ASDE.

16.1.1 Surveillance Architecture Evolution—Step 1 (1998)

En Route Domain. Various models of air route surveillance radar (ARSR-1, -2, -3, and -4) and several military fixed position surveillance (FPS) (military primary radar) types are used to provide primary radar surveillance for the ARTCC. These radars are positioned to support major airways and provide surveillance coverage within a 200- to 250-mile radius with 10- to 12-second update rates. Except for the ARSR-4, many of these radars have been in service for 30 years and are costly to operate and maintain. The ARSR-4 radars in the continental United States and the FPS-117 radars in Alaska are jointly used by the FAA and the Air Force for ATC and air defense, respectively.

Two types of SSRs are used: the ATCBI-4 and -5 and the Mode-S. Nearly all SSRs are co-located with en route primary radars and operate at equivalent ranges and update rates. Twenty-two SSRs operate as stand-alone radars supporting ARTCCs. The ATCBI-4s and -5s are reaching the end of their service lives and will be replaced.

Oceanic Domain. In current operations, pilot position reports are made to a commercial service via high frequency (HF) voice communications. They are then forwarded to FAA oceanic ATC centers where the reported positions are displayed to controllers. Some pilot position reports are currently being transmitted from FANS-1/A-equipped aircraft via satellite data link using controller-pilot data link communications (CPDLC) messages to some oceanic sectors.

Terminal Domain. Three models of airport surveillance radar (ASR-7, -8, and -9) are positioned on airports to provide surveillance coverage (55-mile radius with a 5-second update rate) for TRACONs. The analog ASR-7 and -8 radars, which have been in service since the 1970s, are incompatible with the future digital terminal automation system, the Standard Terminal Automation Replacement System (STARS). Two types of SSRs are used in the terminal domains: the ATCBI -4 and -5 and the Mode-S. They are all co-located with ASRs and operate at equivalent ranges and update rates.

Tower/Airport Surface Domain. ASDE radars, used to provide primary radar surveillance of aircraft and vehicles on airport runways and taxiways to air traffic control towers (ATCTs), are being installed at the 34 busiest U.S. airports. The Airport Movement Area Safety System (AMASS), being installed at the same airports, works in conjunction with the ASDE-3 to alert tower controllers of impending runway incursions and other ground traffic problems. A parallel runway monitor (PRM) radar has been commissioned at the Minneapolis and St. Louis airports to monitor aircraft on approach to closely spaced parallel runways (separated by less than 4,300 feet).

16.1.2 Surveillance Architecture Evolution—Step 2 (1999–2002)

En Route Domain. The weather and radar processor (WARP) will enable weather data from the next-generation weather radar (NEXRAD) to be displayed to en route controllers on the display system replacement (DSR). This capability will allow en route primary radars to be shut down. Data from the ARSR-1, -2, -3, - 4, and FPS primary radars will not be used by FAA after WARP reaches full operating capability (FOC) (i.e., provides NEXRAD data to DSR) in early 2000. However, the long-range primary radars that support Department of Defense (DOD) operations (i.e., FPS-117 and ARSR-3 and -4 radars) may remain in use as required by DOD or other agencies. An ARTCC may receive data from suitably located terminal radar equipment, as needed, for supplemental coverage and gap filling.

The en route SSRs (ATCBI-4 and -5) will be replaced with a new ATCBI-6 with SI capability. ARSR-1, -2, and -3 and FPS site equipment and components, including the radar towers and pedestals, rotary joints, and shelters will require modification or replacement to allow compatibility with an SSR-only configuration.

Oceanic Domain. Oceanic sectors will continue to receive pilot position reports from FANS-1/A-equipped aircraft via satellite data link using CPDLC messages, as well as from HF voice communications.

Terminal Domain. The ASR-9 radars will receive a service life extension. The ASR-7 and -8 radars will be replaced by new digital ASR-11 radars delivered with a new monopulse SSR. Digital radars are required for interoperability with STARS.

To take early advantage of the information available in ADS-B avionics, the architecture plans for all SSRs to be equipped with a selective interrogation capability. The Mode-S sensors currently paired with ASR-7 and -8 radars will be "leap-frogged" to ASR-9 sites, so that all ASR-9s will be paired with SI-capable Mode-S SSRs. Mode-S sensors will receive a service life extension. All SSRs will remain compatible with the older Mode-A/C transponders, thus allowing time for aircraft to transition to ADS-B avionics.

TIS, a Mode-S data link service that provides automatic traffic advisories to properly equipped aircraft, will be implemented during this period. Pilots will be able to request and receive a display of nearby traffic. The relative range, bearing, and altitude (if known) and a "proximate" or "threat" classification of nearby aircraft will be displayed. This service will help pilots "see and avoid" other aircraft.

Tower/Airport Surface Domain. Installation of ASDE-3 radars to detect aircraft and vehicles on runways and taxiways will be completed at 34 airports. AMASS, which uses data from the terminal automation and ASDE-3 systems to alert tower controllers to potential traffic conflicts, will be installed at the same airports during this period. Installation of a new surface surveillance conflict detection system will begin at additional airports. This capability will further reduce the probability of traffic conflicts on airport surfaces and increase the efficiency of aircraft operations. Installation of PRMs at four additional airports is planned.

Additional Information. The user aviation community is currently investigating ADS-B for air-air surveillance. Several technologies—including 1090 MHz (Mode-S) squitter, self-organizing time division multiple access (STDMA) (also known as VHF digital link-Mode 4 or VDL-4), and Universal Access Transceiver (UAT)—are being tested. During this period Safe Flight 21 ADS concept demonstrations will be conducted to determine if and how ADS-B and ADS would operationally benefit users and the FAA and which technology is most suitable for this purpose.

If enough users equip with ADS-B avionics, the FAA will develop and install a compatible ADS ground system. In domestic airspace, ADS will depend upon the aircraft to automatically and frequently broadcast its position and velocity using ADS-B avionics.

Surveillance tracks derived from ADS-B data are expected to be more accurate than radar-derived tracks, thus improving the performance of controller decision support systems (DSSs) such as conflict probe, trial flight planning (a capability that evaluates pilot requests for revised flight paths for potential conflict with other flights), and FAST. Such improvements will help expedite traffic flow in the NAS.

Should users equip, ADS-B for air-air surveillance will be implemented in domestic and oceanic airspace. ADS-B is anticipated to support air-air surveillance by means of a cockpit display of traffic information (CDTI) that shows the position of all ADS-B-equipped aircraft nearby as a reference for tactical maneuvering, self-separation, and station-keeping. This will greatly enhance situational awareness in the cockpit. In domestic airspace, pilots are expected to use ADS-B air-air surveillance for situational awareness and limited shared responsibility for separation. These capabilities are expected to primarily benefit air carrier and cargo operations, but would be helpful to all of aviation as well. ADS-B avionics will not be required to operate in the NAS. In oceanic airspace, ADS-B may also be approved as a means for pilots to conduct in-trail climbs, descents, and passing maneuvers.

16.1.3 Surveillance Architecture Evolution—Step 3 (2003–2006)

En Route Domain. The Mode-S and ATCBI-6 SSRs will be upgraded with the All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX) surveillance and weather message transfer protocol that was developed by the European Civil Aviation States to standardize data communications between surveillance and automation systems. This upgrade will allow the aircraft navigational system and waypoint data received in GICB replies to be processed. Mode-S sensors will receive a service life extension.

The ARTCC automation system will be upgraded to use GICB and ADS data for controller tools and displays (see Section 19, En Route). Installation of the ATCBI-6 SSRs will be completed.

Oceanic Domain. Installation of communications, and automation equipment to support ADS-A will begin. Current longitudinal separation standards between suitably equipped aircraft could be reduced in some areas by using ADS-A and other controller tools.

Terminal Domain. Mode-S SSRs will be upgraded with ASTERIX. The ASR-11's SSR will be upgraded with SI capability and the ASTERIX standard interface protocol. This will enable the ASR-11 SSR to send the aircraft position, velocity, and next waypoint data received via the GICB message to the STARS automation. STARS will be upgraded to use GICB and ADS data for controller displays (see Section 23, Terminal).

Tower/Airport Surface Domain. Installation of the new surface surveillance and conflict detection system will continue. If enough users equip with ADS-B avionics, installation of about 600 passive ADS ground stations with multi-lateration capability for airport surface surveillance will begin at approximately 150 airports. The multi-lateration capability enables the ADS system at an airport to determine the position of aircraft equipped with Mode-A/C/S transponders.

ADS-B avionics, which use WAAS and LAAS information, will provide the ADS source to precisely monitor the surface movement of ADS-B-equipped airport traffic. Due to its expected accuracy, LAAS is preferred for surface surveillance. The airport surface ADS system will interface with the STARS automation and displays to provide precision surface surveillance and warn tower controllers of impending runway incursions and other ground traffic problems. The STARS automation system will be capable of processing the ADS data. AMASS will receive a service life extension to ensure its viability.

16.1.4 Surveillance Architecture Evolution—Step 4 (2007–2010)

En Route Domain. If enough users equip with ADS-B avionics, the architecture plans for the installation of 20 passive ground stations in airspace not covered by radar. This capability will provide extended en route surveillance coverage for ADS-B-equipped aircraft. An additional 96 passive ADS ground stations will be installed in the en route airspace covered by radar.

Oceanic Domain. Implementation of ground-based and airborne communications and automation equipment to support ADS-A and ADS-B air-air surveillance will continue. Oceanic airspace users will benefit through greater flexibility, increased user-preferred routes and climbs, and greater capacity.

Terminal Domain. If enough users equip, passive ADS ground stations will be installed to provide ADS for up to 150 terminal areas. Target data from the ADS ground stations will be processed for display on TRACON controller workstations. The ADS system will also be used for monitoring instrument approaches to closely spaced parallel runways.

Tower/Airport Surface Domain. AMASS functionality will be incorporated into the tower automation system and installation of ADS ground stations will be completed. Installation of the new surface surveillance and conflict detection system also will be completed.

16.1.5 Surveillance Architecture Evolution—Step 5 (2011–2015)

En Route Domain. En route surveillance will be provided by SSRs and ADS. FAA-funded replacement of primary en route radars is not contemplated.

Terminal Domain. A next-generation terminal radar (multipurpose airport radar (MPAR)), which incorporates primary radar, SSR, and terminal Doppler weather radar capabilities, will begin to replace the existing systems starting about 2015.

Tower/Airport Surface Domain. ASDE systems will be decommissioned at the end of their service lives. Surface surveillance will rely on ADS surveillance with multi-lateration or other more cost-effective technologies for preventing runway incursions.

16.2 Summary of Capabilities

The evolution of surveillance capabilities is depicted in Figure 16-2**.**

Air Surveillance

The ADS-B concept is expected to provide an important air-air surveillance capability. Aircraft equipped to receive ADS-B transmissions will be able to display the position of all ADS-B-equipped aircraft in their proximity on CDTI displays. This capability will improve aircrew situational awareness, increase approach and departure efficiencies, and improve oceanic maneuvering. It

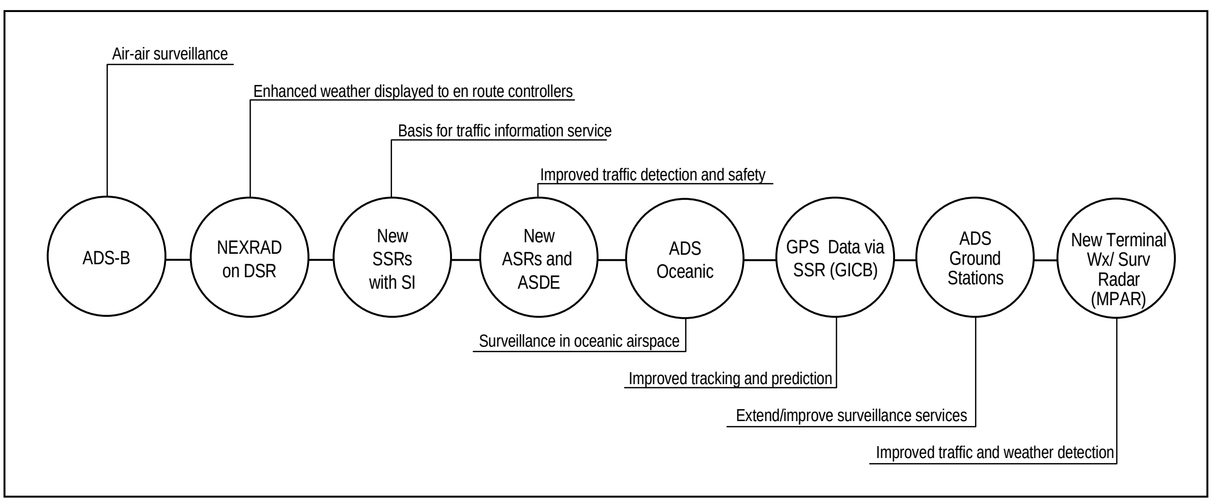

Figure 16-2. Surveillance Capabilities Summary

will enable pilots to assume responsibility for separation in certain circumstances.

Air Traffic Control System

Weather data from next-generation weather radars (NEXRAD) will be available to en route controllers via WARP, enabling long-range primary radars to be phased out. Primary radars will continue in use in terminal airspace and for airport surface surveillance. SSRs will continue in use in both terminal and en route airspace.

ADS will be introduced to provide a surveillance capability in oceanic airspace. The capability is based upon ADS-A, which uses position reports transmitted from FANS-1/A- or ATN-equipped aircraft via SATCOM, HFDL, or other subnetworks.

The terminal primary radar system will become all-digital with significantly improved capabilities, such as better detection of small aircraft at low altitudes and dedicated weather detection and processing. Primary radar for surface surveillance, coupled with conflict prediction capability, will be installed at a significant number of airports to improve surface operations and safety.

All SSRs will have an SI with GICB capability to elicit position and velocity (presumably GPS-derived) from the navigation system of suitably equipped aircraft via the Mode-S transponder. The resultant tracking accuracy will improve the performance of controller automation tools, such as conflict probe and requested flight path (trial planning), which support pilot routing and rerouting preferences.

Implementation of ADS in the domestic airspace (based on ADS-B) will enable surveillance services to be extended to new areas and improved in existing areas. ADS will support surface operations, thereby improving airport utilization during reduced visibility conditions. In conjunction with AMASS, ADS will increase protection against runway incursions. ADS will also improve airport utilization by providing the capability to monitor simultaneous approaches to closely spaced parallel runways in all weather conditions.

16.3 Human Factors

The surveillance systems themselves are not expected to require significant human factors engineering. However, the addition of the new surveillance capabilities (such as those associated with GICB messages and ADS-B, data and target fusion, and new mapping techniques) is expected to levy considerable human factors requirements on the ATC automation displays, aircrews, and controllers. The associated human factors effort will focus on the impact of new surveillance technologies, equipment, and methods on pilots, controllers, and maintainer interfaces, including:

- Identifying informational requirements and integrating information from new or multiple sources (such as the integration of ADS surveillance data with other radar data) in ways to facilitate development or modification of essential DSSs
- Application of reduced minimum separation standards for the controller and aircrews
- Prototyping changes to tasks and procedures that take advantage of new surveillance capabilities (such as SI and increased surveillance accuracy derived from GPS data).

The surveillance capabilities envisioned for the future (such as authorizing an aircrew to use ADS-B CDTI for self-separation) will require development of suitable cockpit displays and procedures. Controllers will require DSS tools to assist them in monitoring and appropriately interceding to ensure safe operations.

16.4 Transition

Primary Radars

Information from en route primary radar systems will not be used for ATC after NEXRAD weather data become available on ARTCC controller displays. It is expected that those radars required by DOD (ARSR-4s, some interior radars, and the FPS-117 radars in Alaska) will be supported by DOD until the end of service life, although current agreements call for FAA maintenance. Terminal primary radars will be retained to provide independent surveillance. The principal transitions are:

- Complete deployment of ASDE-3, ARSR-4, and ASR-9 equipment
- Replace ASR-7 and -8 radars with ASR-11

- Decommission the primary en route radars (ARSR -1, -2, -3, FPS) not required in accordance with FAA/DOD joint agreements
- Deploy new airport surface movement detection equipment with conflict prediction capability
- Perform a service life extension for ASR-9 and ASDE-3/AMASS radars
- Decommission any remaining en route primary radars (ARSR-4, FPS-117)
- Replace ASR-9 and -11 radars with a new terminal radar that includes SSR and terminal Doppler weather radar (TDWR) capability.

Secondary Radars

The SSRs will be retained to provide cooperative surveillance compatible with Mode-A/C transponders and redundancy in case dependent surveillance is interrupted. All SSRs will feature SI capability in order to utilize GICB transponder replies. The principal transitions are:

- Deploy remaining PRM systems
- Upgrade ASR-11 beacon with SI capability
- Replace en route ATCBIs-4 and -5 with ATCBI-6
- Leapfrog Mode-S from ASR-7 and -8 sites to ASR-9 sites
- Upgrade SSRs with GICB and ASTERIX capabilities
- Perform a service life extension for Mode-S radars.

Automatic Dependent Surveillance

ADS in domestic airspace will be based on ADS-B; in oceanic airspace, it will be based upon ADS-A. The Safe Flight 21 program is intended to support development and evaluation of ADS ground stations and the automation processing and display of ADS-derived information. If enough users equip with ADS-B avionics, a successful Safe Flight 21 program is expected to result in deployment of ADS ground stations. Figure 16-3 shows the transition schedule for the ADS systems. The principal transitions are:

- Install oceanic ADS-A capability

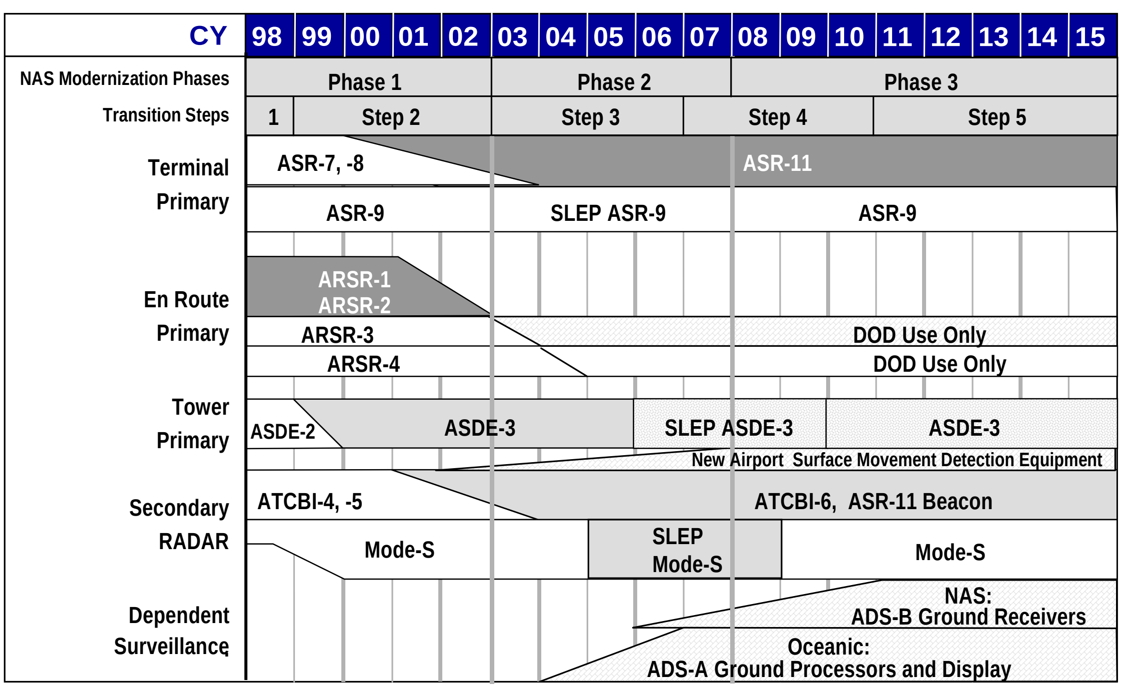

Figure 16-3. Major Surveillance Systems Transition

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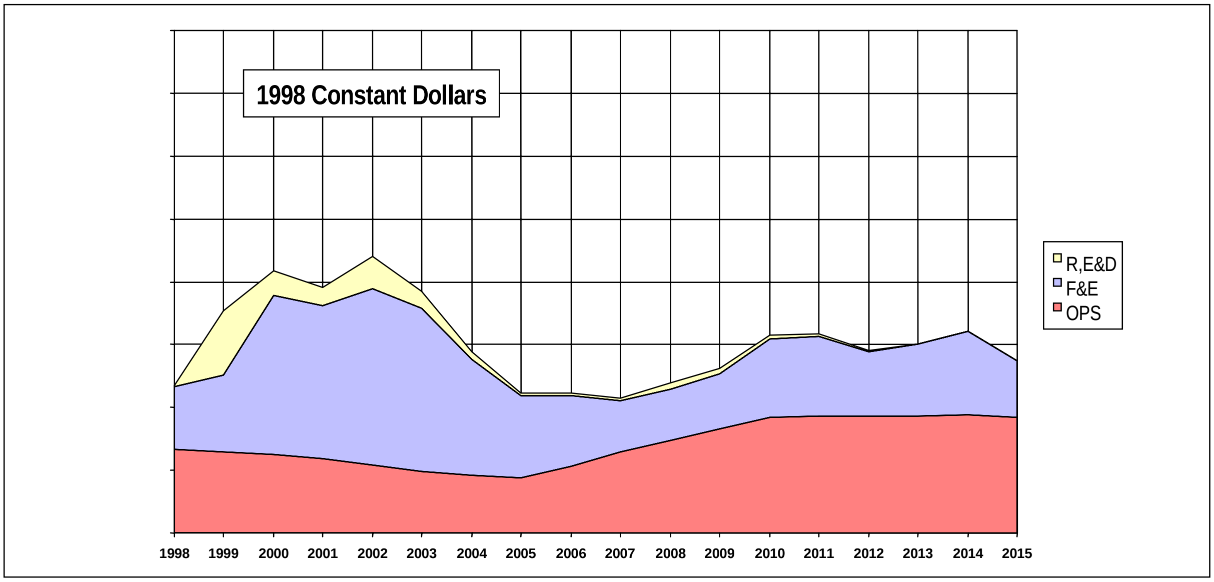

Figure 16-4. Estimated Surveillance Costs

- Complete ADS-B, Traffic Alert and Collision Avoidance System (TCAS), and CDTI standards for air-air surveillance
- Based on air-air surveillance, provide enhanced approach/departure and oceanic maneuvering services
- Develop ADS ground stations and improved surveillance systems via the Safe Flight 21 ADS-B program
- Deploy passive ADS ground stations:

  –To extend en route surveillance coverage to new areas

  –To en route, terminal, and airport surface locations throughout the NAS.

Other Surveillance Support:

- Complete AMASS implementation
- Perform service life extension for ASDE-3 and AMASS.

16.5 Costs

FAA estimates for research, engineering, and development (R,E&D), facilities and equipment (F&E), and operations (OPS) life-cycle costs for surveillance architecture from 1998 through 2015, are presented in constant FY98 dollars in Figure 16-4.

16.6 Watch Items

Decommissioning long-range primary radars depends on the availability of a WARP-provided NEXRAD weather data presentation on the new ARTCC displays now being installed. The WARP program is on schedule to be fully operational in all ARTCCs during Step 2.

ADS, based on ADS-A and ADS-B, is the major new ground surveillance capability envisioned for oceanic and domestic airspace, respectively. The initial development and evaluation of ADS, as well as ADS-B for air-air surveillance, depends on a number of significant technological developments involving avionics and ground equipment, and operational demonstrations planned for the Safe Flight 21 program, slated to occur during Step 2. Results of the Safe Flight 21 demonstrations will be subject to evaluation by both the FAA (through the Investment Analysis process) and users to determine subsequent investments and implementation in the NAS. It is evident that FAA and user decisions must be linked, because ADS is dependent on user investment in avionics. Avionics manufacturers are expected to create and integrate GPS-WAAS/LAAS receivers and ADS-B avionics for aircraft slated to participate in Safe Flight 21.

To use aircraft-derived position data for surveillance and tracking, the SSRs must all be configured with SI and ASTERIX in Steps 2 and 3. ATC automation systems will need to be configured to receive and process the enhanced surveillance data.

A major watch item is the rate at which users install ADS-B avionics during Steps 2, 3, and 4. The rate of equipage will be determined by factors such as avionics cost, availability, and perceived user benefits. The realization of expected user benefits, such as improved vectoring and sequencing and flexible routes, will depend on the rate of user equipage, procedural development, and FAA capability to process GPS data provided by aircraft avionics.

This architecture continues to provide surveillance, independent of user equipage with ADS-B. However, the FAA will deploy ADS-B listening (ground) stations as users equip with ADS-B avionics. A long transition period to ADS-B is anticipated. This requires the FAA to continue providing surveillance services using primary and secondary radar.

ADS in oceanic airspace will be based on position reports data linked by satellite, high frequency data link, or other subnetworks to FAA oceanic controllers. Airlines are ordering the FANS avionics needed for navigation and data link reporting via SATCOM. The FAA program to acquire the reciprocal necessary ground equipment and automation capabilities is under consideration.

17 COMMUNICATIONS

The NAS communications architecture provides a plan for achieving reliable, timely, efficient, and cost-effective transfer of information among NAS users and between NAS users and the external environment. It addresses communications technology and standards, telecommunications system integration and partitioning, network operations and management, and transition. The architecture meets the concept of operations (CONOPS) requirement for seamless communications across domains and information sharing among all NAS users. It also provides for the subnetworks needed to support NAS resectorization in the future.

In order to facilitate the NAS architecture planning process, the communications system is divided into three elements: Interfacility Communications, Intrafacility Communications, and Mobile Communications.

- *Interfacility Communications:* Consist of the networks that transmit voice, data, and video information among FAA facilities and that connect to external facilities. Interfacility communications connect with intrafacility communications and mobile communications.
- *Intrafacility Communications:* Consist of the networks that transmit voice, data, and video to users within a facility. Intrafacility networks interface with interfacility networks to connect users within a given facility to users in other facilities or to mobile users.
- *Mobile Communications:* Consist of networks that transmit voice and data among mobile users. These networks interface with interfacility networks to provide communications paths between mobile users and users within a facility. Two types of mobile communications networks are used in the NAS: air-ground communications networks that support air traffic control and ground-ground networks that support maintenance and administrative activities.

Information exchange among NAS users involves one or more of these elements. Air-ground communications, for example, use all three elements of the communication system. Various applications of the communications system are further described in Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; and Section 24, Tower and Airport Surface. The data link system and services are described in Section 17.1.4, Data Link Service.

17.1 Communications System Evolution

The FAA has traditionally considered communications networks in terms of air-ground voice communications, ground-ground operational voice and data communications, and agency (administrative) voice and data communications. The communications architecture proposes to integrate these networks to improve interoperability, quality of service, network security, and survivability while reducing the cost per unit of service.

Most ground-ground transmission systems will be consolidated within a common network infrastructure that will integrate administrative and operational communications systems for interfacility transmission of voice, data, and video.

The NAS will migrate to a digital telecommunications infrastructure to take advantage of new technology and the growing number of digital services. The telecommunications infrastructure will also support current analog voice switches and legacy protocols.

The domestic air-ground system will migrate to digital technology for both voice and data communications. Oceanic communications will migrate to International Civil Aviation Organization (ICAO)-compliant aeronautical telecommunication network (ATN) data link applications using high frequency (HF) and satellite-based links.

17.1.1 Interfacility Communications System Evolution

The NAS interfacility system is expected to lower communications costs while providing qualitative service improvements and future growth capacity. A decisive change at this time is critical for two reasons. First, new data communications requirements will greatly increase recurring costs unless a significant communications redesign occurs now. Second, the upcoming expiration of the Federal Telecommunications System 2000 (FTS 2000) and Leased Interfacility NAS Communications System (LINCS) transmission facilities

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and service contracts are likely to provide the timing window for significant improvements that the FAA must be prepared to take advantage of.[1] When completed, the NAS interfacility communications system will consist of several logical networks supported by a predominantly leased physical infrastructure. This logical and physical network architecture is essential to NAS modernization.

Logical Network

Design. The interfacility communications system will provide a set of software-defined networks that are logically partitioned to provide connectivity between facilities. Each logical partition will support independent virtual private networks (VPNs) that share common telecommunications resources. VPNs have most of the features of a private network while providing very reliable communications at a lower unit cost.

The interfacility communications system will consolidate networks in order to transport operational and administrative traffic over the same physical links. However, traffic will be logically partitioned into four (or more) virtual private networks—two for voice and two for data and video (see Figure 17-1). Other VPNs may be added to meet special needs (e.g., security requirements may require a separate VPN for Internet communications).

Common Physical Network Infrastructure.

The common physical network infrastructure is a shared physical networking environment that includes transmission, switching, multiplexing, and routing facilities. The common physical network infrastructure uses VPN technology to meet different administrative and operational performance requirements. It will also use a mix of transmission services and service providers to achieve the desired level of reliability and path diversity at the lowest cost.

The current physical communication networks consist of transmission systems (e.g., LINCS, radio communications link (RCL), and television microwave link (TML)); switching systems (e.g., National Airspace Data Interchange Network packet switch network (NADIN PSN)); and mul-

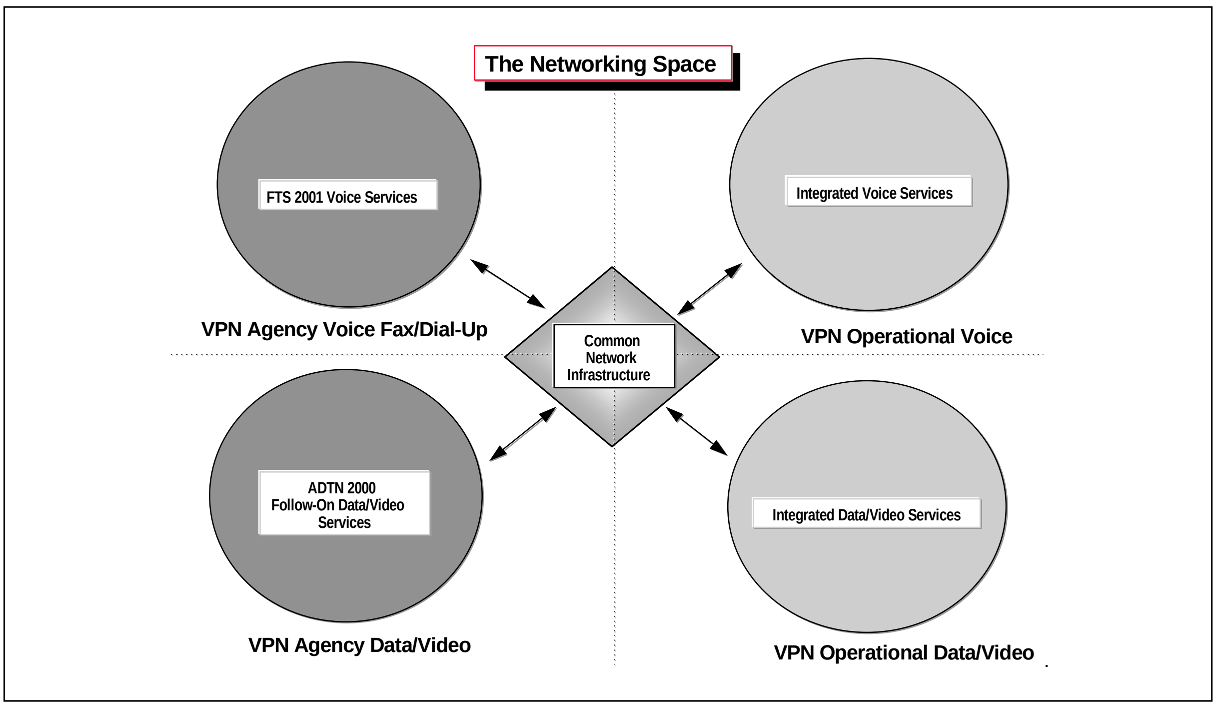

Figure 17-1. Logical Network Architecture

1. Note that the integrated communications system procurement does not include the following: air traffic control voice switches, the Alaskan NAS Interfacility Communications System (ANICS) ground infrastructure, digital airport telecommunications, administrative dial switches, or air-ground and mobile communications equipment and services.

tiplexing systems (e.g., data multiplexing network (DMN)). In the future, digital switches or routers at each ARTCC will replace existing multiplexer equipment. These various networks will be integrated by using a single transmission technology, such as asynchronous transfer mode.

Asynchronous transfer mode technology allows the replacement of dedicated physical trunks with virtual private trunks for operational traffic (currently the largest communications expenditure). It also provides a number of bandwidth-saving efficiencies, including channel release during moments of audible silence and compression of administrative voice (currently the largest traffic category). This technology can also provide multicasting, dynamic bandwidth allocation, quality of service guarantees, priority and preemption for critical and essential services, and survivability for operational-critical and essential services.

Each user application, whether operational or administrative, is assigned its own quality-of-service and priority. The highest priority would be used for critical operational traffic. Low-priority traffic would use the gaps between higher-priority traffic and any overflow capacity. Use of asynchronous transfer mode over satellite links, particularly over the FAA Telecommunications Satellite System (FAATSAT), could also provide better bandwidth utilization and better integration with terrestrial networks.

Frame-relay technology appears to be useful for data applications at sites where the total data requirement for network access is in the 64 Kbps to 1.544 Mbps range. This would require installing frame-relay access devices at small FAA sites. The frame-relay access devices can be connected to either a frame relay or an asynchronous transfer mode network.

Agency Voice VPN/Fax/Dial-Up. Voice services available through the Federal Telecommunications System (FTS 2000) contract will be replaced by an integrated telecommunications infrastructure that provides different classes of network connections and virtual circuits for all voice services needed to support FAA administrative functions. The classes of services implemented in the administrative voice VPN will depend on user needs. Those requiring high availability, for example, may receive dedicated bandwidth, while less critical voice services may receive a variable bit rate service that consumes less bandwidth and maintains low connect times.

Agency Data/Video VPN. VPN services provided by the integrated telecommunications infrastructure will be used for data networking, facsimile, dial-up, and video services needed for FAA business operations. Services will be assigned priorities according to business operations requirements. The integrated telecommunications infrastructure will also feature networking schemes to manage transmission control protocol/Internet protocol (TCP/IP)-based information and administrative data and video information.

Operations Voice VPN. VPN services provided by the integrated telecommunications infrastructure will be used for voice communications for NAS operations. This VPN will have the highest priority service in order to meet NAS voice operational requirements. Operational voice services requiring extremely high availability may be configured with a permanent virtual circuit class of service that provides dedicated connectivity. The operations voice VPN will include major air traffic facilities, such as air route traffic control centers (ARTCCs), terminal radar approach control (TRACON) facilities, and airport traffic control towers (ATCTs).

Operations Data/Video VPN. VPN data and video services available in the integrated telecommunications infrastructure will provide the data networking and video capability needed for NAS operations. The logical network design employed within the VPN framework will satisfy operational requirements for critical data and video services by using the appropriate class of service connections.

Physical Network Design

External Interfaces. Gateways and routers will provide external communications interfaces for the Department of Defense (DOD), aviation industry users, service providers, and international agencies. Access gateways or routers will be used between the appropriate FAA VPN and the airline operations center network (AOCNet). Aviation industry access will facilitate traffic flow management (TFM), collaborative decisionmaking (CDM), and other similar initiatives.

Network Management and Operation. The integrated telecommunications infrastructure will interface with the operations control centers and exchange both real-time and non-real-time information. The telecommunications infrastructure will provide the following network management services:

- Real-time information exchange
  - User help desk for service restoration and coordination
  - Network performance statistics
  - Hardware and software configuration
  - Remote equipment status
- Electronic security
- Non-real-time information sharing
  - Network statistics
  - Network planning
  - Billing and accounting data
  - Port utilization data.

17.1.1.1 Interfacility Communications System Evolution—Step 1 (Current–1998)

It is estimated that the FAA employs more than 25,000 interfacility point-to-point and multipoint circuits for air traffic services—of which roughly 60 percent are used for voice and 40 percent for data. FAA voice and data communications are often combined (multiplexed) over backbone transmission systems, although they are generally handled separately on the access networks.[2] Most voice and data circuits are leased on a monthly basis from communications service providers. Of the approximately $300M spent by the FAA on telecommunications in FY95, nearly 60 percent was for recurring circuit costs.

Today's interfacility operational voice communications are based on voice switches with analog voice output. Since the vast majority of interfacility voice trunks are digital (provided by LINCS), the analog voice signal must be digitized before it is transmitted. Operational voice circuits are usually configured as dedicated point-to-point and multipoint circuits and are used only a few minutes per hour.

Voice switches in the current system are not capable of switching calls through to another switch (tandem switching) and typically do not provide supervisory signaling. In cases where supervisory signaling is provided, it is typically provided inband, which forces switches to rely on dedicated point-to-point or multipoint circuits for connectivity to other switches. This results in a highly inefficient use of communications bandwidth, given the NAS voice traffic loading profile.

Today's interfacility data communications provide a variety of circuits and connection types between FAA sites. At the transmission level, RCL, TML, and low-density radio communications link (LDRCL) use analog and digital microwave circuits; FTS 2000 and LINCS use copper and optical fiber circuits; and Alaska NAS Interfacility Communications System (ANICS) and FAATSAT use satellite circuits. The FTS 2000 contract expired in 1998 and will be replaced by the FTS 2001 contract.

The data switching environment largely consists of separate, lightly loaded, low-bandwidth networks. The technologies used include a 1960's message switch network (i.e., NADIN message switch network (MSN)), several 1970's asynchronous systems used for weather data collection and distribution, a 1970's X.25 packet switch network (i.e., NADIN PSN), which is currently being upgraded to modern frame-relay capabilities, and a DMN that uses analog transmission circuits. Each network is administered, operated, and maintained separately and is generally unable to back up the other networks.

One way the FAA is improving network efficiency is through the use of bandwidth management systems that are capable of switching between independent transmission networks (e.g., RCL, LINCS, FAATSAT). Bandwidth management provides the ability to multiplex voice and data over higher-capacity trunks when it is cost-effective and simplifies transition to other service providers.

2. Low-speed data circuits are routinely combined on the FAA's DMN to achieve cost savings on interfacility circuits.

Except for high-end video conferencing, all agency data requirements are met by the Administrative Data Transmission Network 2000 (ADTN 2000). ADTN 2000 employs multiprotocol routers in conjunction with a frame-relay core to carry monthly traffic in excess of 300 gigabytes with an average delay under 200 milliseconds and availability of 0.999.

17.1.1.2 Interfacility Communications System Evolution—Step 2 (1999–2008)

To meet FAA communications growth in the next century, the interfacility communications system consolidates most of the transmission systems and voice and data networks within a single integrated communications infrastructure that offers integrated voice, data, and video services across the NAS. The new telecommunications infrastructure will provide improved performance at a lower unit cost.

The NAS ground-ground operations voice network will transition from a point-to-point network using dedicated trunks to a switched network that provides bandwidth on demand. The FAA will migrate from analog switch interfaces that use in-band signaling to digital interfaces and out-of-band signaling. Air traffic control (ATC) switches that currently use digital technology will have analog interfaces replaced with digital interfaces. Switches based on analog technology such as the small tower voice switch (STVS) will be provided, if cost-effective, with ear and mouth (E&M) signaling and connected to a channel bank or a network termination device in order to interface with the digital network. Future voice switches will not require legacy interfaces.

Data communications to international air traffic services (ATS) facilities will evolve from the existing aeronautical fixed telecommunications network (AFTN) infrastructure to an ATN-based infrastructure. Most of the FAA's telecommunications systems (RCL, LINCS, FTS 2001, NADIN MSN, NADIN PSN, and the bandwidth manager) will be incorporated in the integrated telecommunications infrastructure.[3]

ANICS, FAATSAT, and the DMN will be integrated next. The LDRCL, however, will remain in service as a separate FAA-owned transmission system. Figure 17-2 provides an overview of the NAS interfacility environment as it will appear in this step. Edge devices (e.g., the edge/access device shown in Figure 17-2) will physically interconnect the integrated backbone network with legacy local area networks (LANs) and switches. These edge devices will initially route internetwork packets, but may evolve to provide both routing and switching functions. NADIN MSN

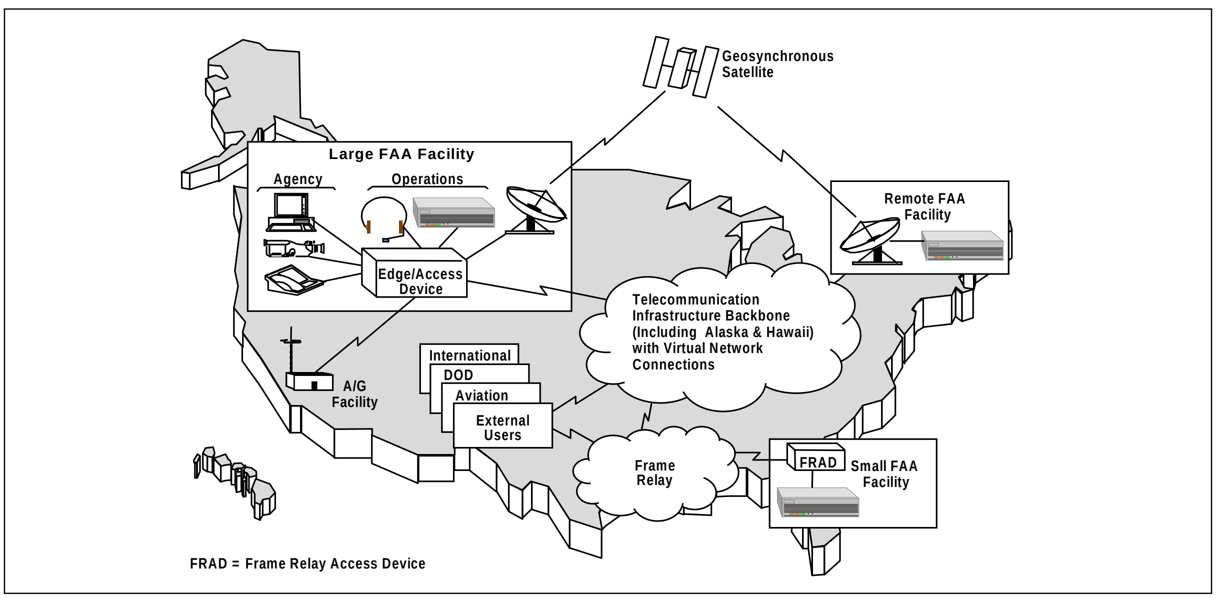

Figure 17-2. Interfacility Architecture in 2008

3. Mission Need Statement (MNS) *FAA Telecommunications Infrastructure* was approved in May 1998.

will be rehosted and will connect directly to an edge device.

17.1.1.3 Interfacility Communications System Evolution—Step 3 (2009–2015)

The interfacility communications system looks the same as the previous step, but undergoes technology refreshment, speed increases on access trunks, and a new generation of NAS voice switches with modern network interfaces is introduced. In addition to these qualitative improvements, cell-based multimedia networks are expected to become available at competitive prices from several vendors. In hard-to-service locations where access costs do not support diversity today, the FAA may employ switched access to low earth-orbiting (LEO) and medium earth-orbiting (MEO) satellite-based networks. Many LDRCLs will be phased out by competitively priced services available from communications carriers. Where such service is not available, LDRCL will remain.

17.1.1.4 Interfacility Communications Schedule

Transition of interfacility communications begins with replacement of the General Services Administration (GSA) FTS 2001 contract. This will be followed by implementing the integrated telecommunications infrastructure, which includes LINCS replacement. LINCS circuit cutover and network conversion schedules will be based on a 2-year transition period. These cutovers will be as expeditious as possible to reduce the time needed to support two networks. For safety, the old network service will be maintained after cutover until the new service has proven itself in a live environment. The communications transition schedule shown in Figure 17-3 assumes a multiyear conversion period that minimizes the impact on FAA staff and ensures a sufficient period of dual operation.

17.1.2 Intrafacility Communications System Evolution

Intrafacility data communications evolution will follow an approach similar to that used in the current administrative system (i.e., widespread use of commercial off-the-shelf (COTS) client-servers and LAN/IP-based networks connecting operational sites). This evolution is already in progress in a large number of major programs, (e.g., the display system replacement (DSR), Standard Terminal Automation Replacement System (STARS), weather and radar processor

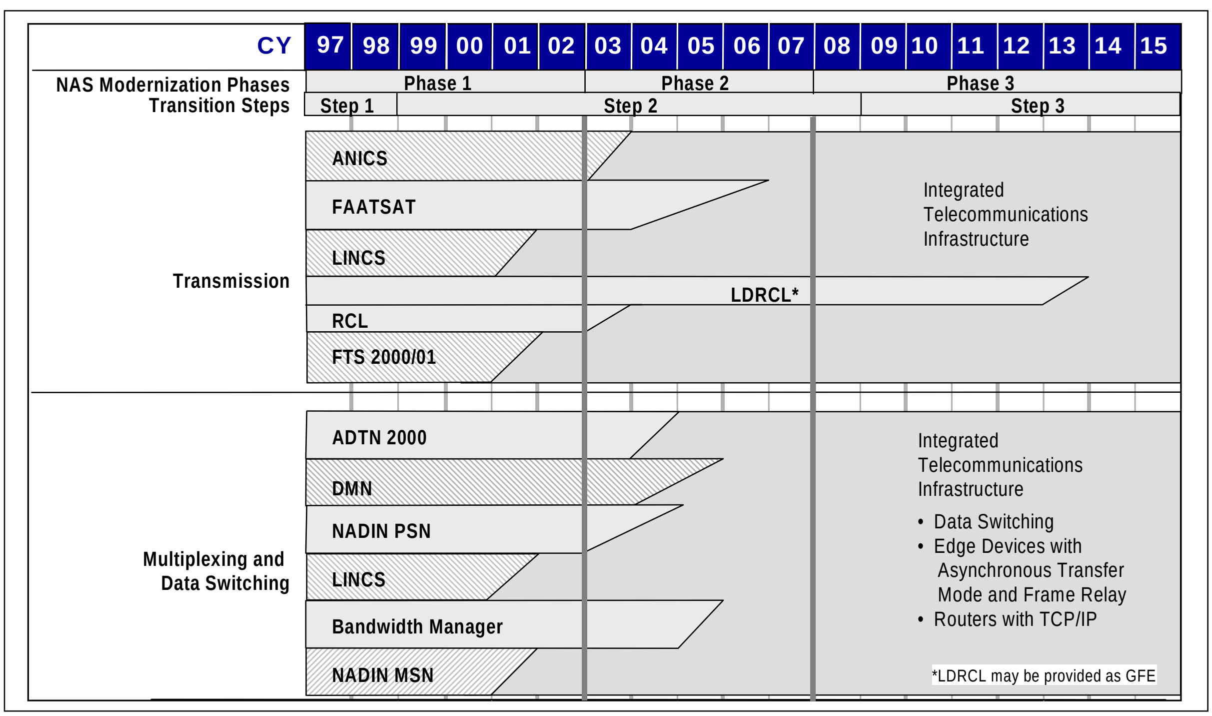

Figure 17-3. Interfacility Communications Transition

(WARP), center TRACON automation system (CTAS), enhanced traffic management system (ETMS), Operational and Supportability Implementation System (OASIS), and host interface device (HID)/NAS LAN). Like the interfacility network that connects operational sites, a number of special features are needed at ATC sites to ensure high availability (e.g., physical, electrical, and power diversities). The basic system components (i.e., LANs, routers, switches, and security access servers) are common to both the interfacility and intrafacility environments and will also provide support for low-speed video transmission.

Intrafacility ATC voice communications will continue to be provided by FAA-owned switches for the foreseeable future.

17.1.2.1 Intrafacility Communications System Evolution—Step 1 (Current–1999)

Today's intrafacility system carries all voice and data communications exchanges within facilities and provides services tailored to the largest ARTCCs and TRACONS as well as the smallest towers.

There are approximately 480 air traffic services voice switches consisting of eight different models from three vendors. These voice switches come in various sizes and configurations and include the STVS, rapid deployment voice switch (RDVS), integrated communications switching system (ICSS), traffic management voice switch, voice switching and control system (VSCS), emergency voice communications system (EVCS), and the soon-to-be-deployed enhanced terminal voice switch (ETVS). The intrafacility intercom services they provide are fundamentally the same in each.

Virtually all intrafacility data communications occur at speeds of 64 Kbps or slower. Although planned, there are no general-purpose LANs in the air traffic data environment today. The result is that each local system must be directly connected to another system it shares information with. The addition of new automation software and hardware combined with the large number of protocols and interfaces required thus results in a complex and hard-to-maintain system. The physical accumulation of wiring in many sites also poses severe restraints on access and upgrades.

The administrative data environment is supported by the Office Automation Technology Services (OATS) contract, which provides modern personal computers and Ethernet LANs for all of its office facilities.

17.1.2.2 Intrafacility Communications System Evolution—Step 2 (2000–2004)

Existing data communications (such as weather) will be transitioned to IP-based communications protocols. Surveillance data will be converted into a common format, the All Purpose Structural EUROCONTROL Radar Information Exchange (ASTERIX), for transmission of data from radars to ARTCCs and TRACONs. IP multicasting capabilities will route data collected for one application (e.g., surveillance, WARP, and integrated terminal weather system (ITWS)) to other applications (e.g., those for air traffic management).

Some agency LANs and facility cabling may be incorporated in the integrated communications infrastructure, leaving existing LANs (i.e., HID, STARS) in place. Figure 17-4 provides an overview of the NAS intrafacility environment in this step.

Voice switches in this step will continue to provide their current intrafacility functions.

17.1.2.3 Intrafacility Communications System Evolution—Step 3 (2005–2015)

Edge switches will be deployed, intrafacility communications speeds will increase, and protocol standardization will be established in the LAN domain. Deployment of fewer, more versatile protocol stacks will reduce maintenance support and troubleshooting and improve interfacility and application-to-application communications. The telephony environment is expected to be integrated via a cell-based protocol running over the LAN; this opens the possibility of higher levels of integration (i.e., data, video, and voice). Currently, gigabit LANs are being developed by industry, and standards are being redefined.

The FAA will acquire a new generation of ATC voice switches to replace its aging and hard-to-maintain inventory. The next generation of digital switches will likely come in several sizes and will meet the requirements of the future ATC voice network. Voice switches will provide the in-

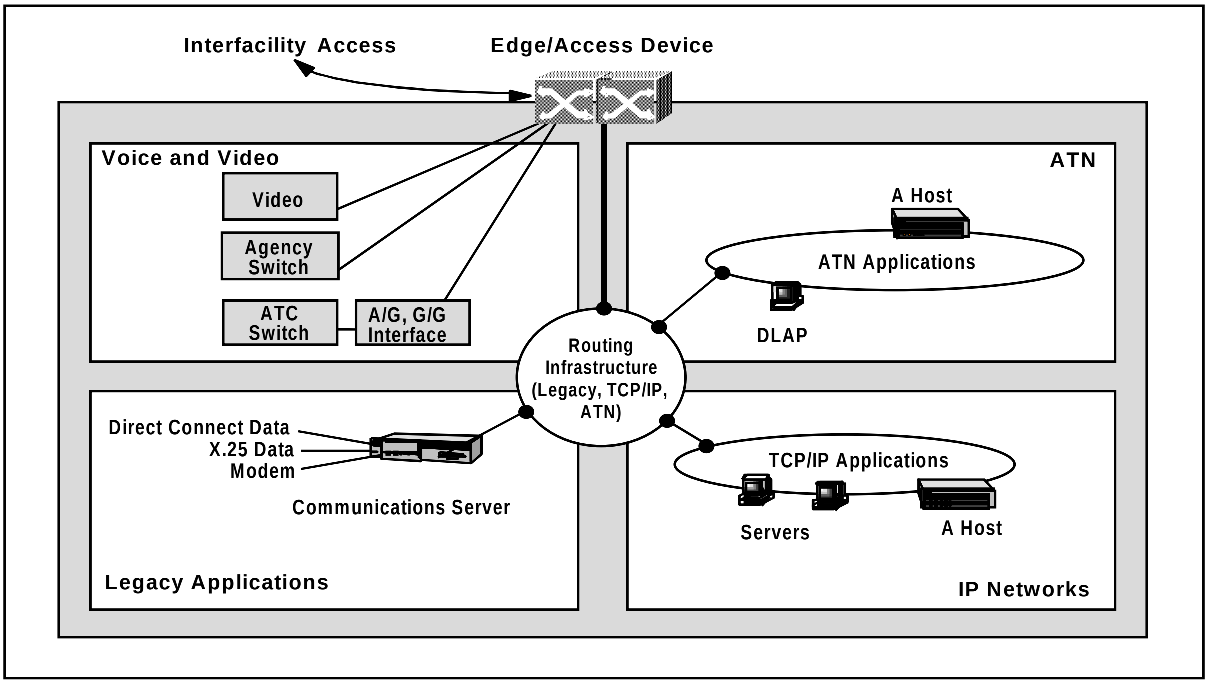

Figure 17-4. Intrafacility Architecture in 2004

trafacility functions required to support the new CONOPS.

Because of the high cost of customized switches, a number of smaller FAA facilities, both operational and administrative, might be economically served by off-site switching. Switches will be replaced as follows:

- ICSS, RDVS, and STVS will be replaced by the voice switch replacement system.
- ETVS will be gradually replaced by the voice switch replacement system.
- VSCS will be replaced after 10 years of service.

Figure 17-5 provides an overview of the NAS intrafacility environment in this step.

17.1.2.4 Intrafacility Communications Schedule

The transition to this new intrafacility environment is already in progress as evidenced by the deployment of the American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE) 802.n-compliant HID NAS/LAN and the prototyping of various new IP/LAN-based applications. Figure 17-6 shows the intrafacility communications transition schedule. Under the current acquisition system, application development projects provide their own computer hardware and much of the required communications equipment. This has led to an array of communication equipment types, compounding facility infrastructure and maintenance problems. The new approach stipulates use of COTS equipment (clients, servers, LAN switches, network interface cards (NICs), routers, fax machines, etc.), and, in particular, protocol converters. The integrated telecommunications infrastructure will offer LAN equipment along with site installation and wiring assistance. EVCS will be decommissioned and incorporated into the follow-on integrated communications infrastructure.

17.1.3 Mobile Communications System

The mobile communications system consists of air-ground and ground-ground components. The air-ground component provides communications paths between controllers and pilots in both domestic and oceanic airspace. The ground-ground component (see Section 17.1.3.2) consists mainly of portable radios used by maintenance personnel.

17.1.3.1 Air-Ground Mobile Communications

Current NAS air-ground communications are provided by an analog system using HF, very high frequency (VHF), ultra high frequency (UHF), and satellite communications (SATCOM) radios.

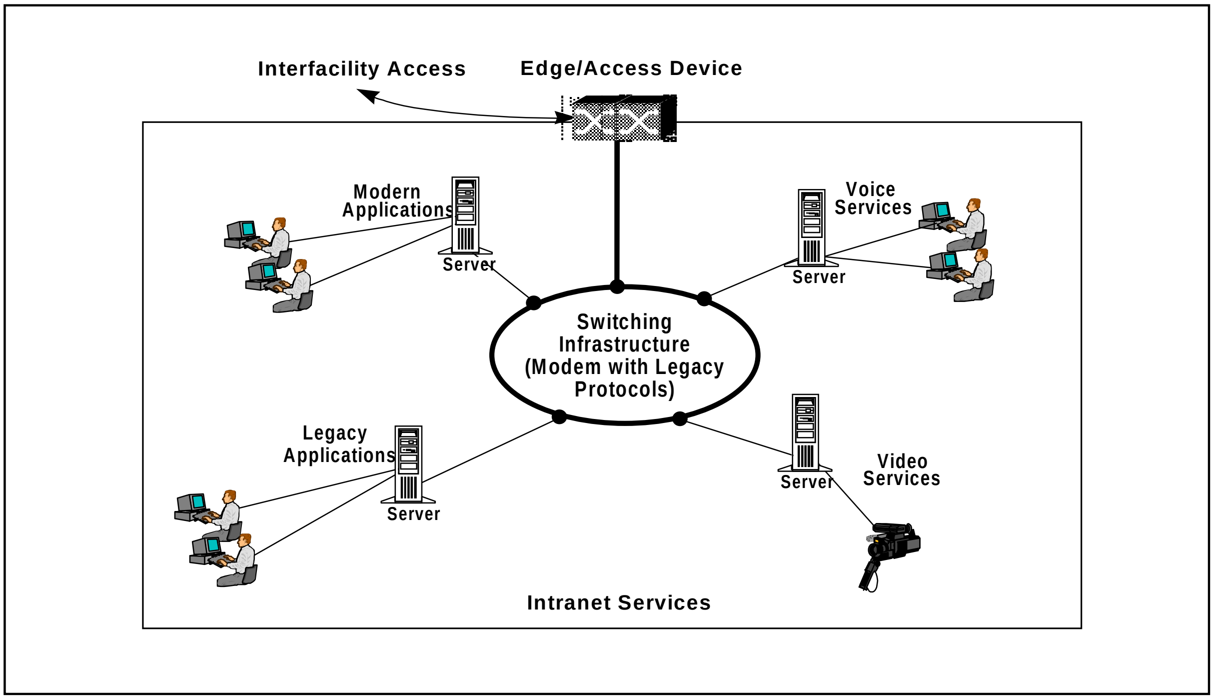

Figure 17-5. Intrafacility Architecture in 2010

Only limited data transmission capability exists in domestic airspace (predeparture clearance and digital air traffic information service) and in oceanic airspace (waypoint position reports via Future Air Navigation System (FANS)-1/A). As the NAS is modernized, however, this balance will shift toward ATN-compliant data communications and attention must be focused on the radios,

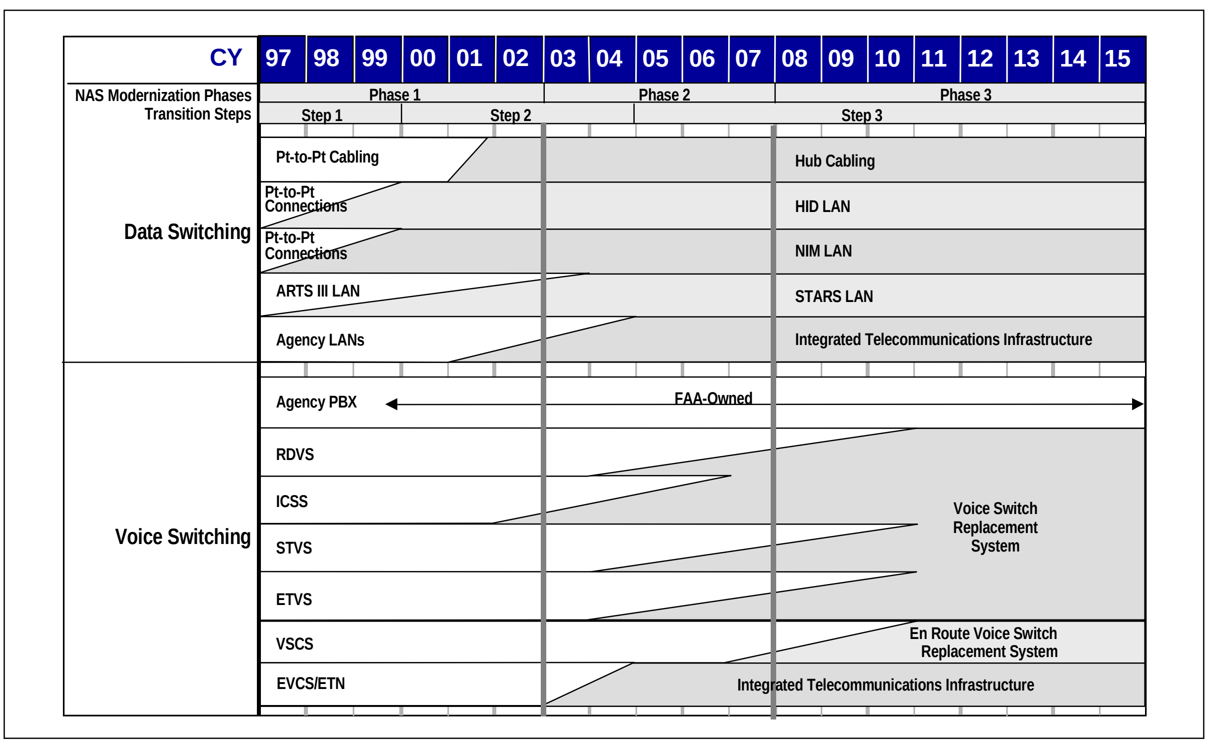

Figure 17-6. Intrafacility Communications Transition

PART III

processors, and applications needed to support data transmission. A discussion of data link systems and services is found in Section 17.1.4. The various applications are covered in Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; and Section 24, Tower and Airport Surface.

In domestic airspace, voice communications for ATC operations are provided by VHF radios operating in the aeronautical mobile communications band (118-137 MHz) and UHF radios operating from 225 to 400 MHz. (UHF is used to communicate with military aircraft.) A 4-percent annual growth in VHF channel requirements over the past 20 years has used up most of the available channels. As a result, current requests for resectorization and new services are being denied in many cases, and certain services, such as weather advisories, are being limited in high-traffic density areas, such as Chicago.

For technical and economic reasons, a joint FAA and aviation industry decision was made to implement very high frequency digital link (VDL) Mode-3 domestically to solve these problems. As a result, the next-generation air-ground communications system (NEXCOM) will be an integrated voice and data system that uses the currently assigned 25 KHz VHF spectrum. This differs from the interim solution planned for European airspace, which subdivides the current 25 KHz spacing into 8.33 KHz channels.

In oceanic airspace, air traffic voice services are provided over HF radio using a communications service provider. The only currently available means by which to conduct oceanic data communications is SATCOM, but high frequency data link (HFDL) service is expected to provide a reliable, low-cost alternative.

Voice communications via HF radio are significantly influenced by atmospheric and solar disturbances. SATCOM voice communications are a reliable alternative but have high installation and transmission costs. Consequently, oceanic communications will evolve from relatively slow HF voice message contacts to short duration SATCOM data messages complemented by HFDL and HF voice. Voice will always be required for nonroutine oceanic communications. Satellite voice—currently being explored for emergency communications—may eventually play a larger role in other communications services.

17.1.3.1.1 Air-Ground Mobile Communications System Evolution—Step 1 (Current–1998)

At the center of air traffic communications is the VHF/UHF air-ground mobile voice communications system. This aging analog system has approximately 50,000 ground-based radios at nearly 4,000 sites. The radios operate in a simple push-to-talk mode, with the same frequency being used for both controller-to-pilot and pilot-to-controller transmissions. There is growing concern over the present VHF communications system because of increasing channel assignment requirements, low channel utilization, voice congestion on high-activity channels, moderate service availability, high failure rates (with older radios), susceptibility to channel blockage (“stuck mike” and “step-on”), increasing radio frequency interference, and lack of security.

In addition to VHF air-ground communications, other currently deployed systems include: Skylinks, which uses HF and satellite communications for oceanic voice and data; recovery communications used by site service technicians; tower data link services (TDLS); and the meteorological data collection and reporting system (MDCRS).

17.1.3.1.2 Air-Ground Mobile Communications System Evolution—Step 2 (1999–2005)

A new service provider network, VDL-2, will be used initially by one ARTCC to provide limited ATC data link service for en route airspace.

The existing domestic air-ground system (composed of VHF radios, backup emergency communications (BUECs), and radio control equipment (RCE)) will continue to provide voice communications during transition to the NEXCOM system. NEXCOM radios will be installed first in all high-altitude and super-high-altitude en route sectors. Initially, all multimode NEXCOM radios will operate in analog mode (i.e., emulate the current radios). En route sectors above Flight Level 240, however, will begin transition to digital voice mode operation near the end of this time period.

Oceanic communications will migrate from primary dependence on service provider HF voice to data link service via satellite and HFDL. HF voice and SATCOM voice will remain available for backup.

Figure 17-7 depicts the mobile communications system (including air-ground communications) as it will appear in this time period.

17.1.3.1.3 Air-Ground Mobile Communications System Evolution—Step 3 (2006–2010)

The ground network infrastructure needed to support data link services over NEXCOM, as appropriate, will be deployed for operation in the ARTCCs.

Most oceanic traffic will complete the transition to HFDL and satellite ATN-compliant data link communications in this time period. A dual protocol stack is planned to maintain compatibility with FANS-1/A-equipped aircraft in the ATN environment.

17.1.3.1.4 Air-Ground Mobile Communications System Evolution—Step 4 (2011–2015)

Selected high-density terminal airspace and the associated low en route sectors will transition to digital NEXCOM service in this period. Civilian aircraft flying instrument flight rules (IFR) in these areas will require NEXCOM radios. UHF radio service will continue until the DOD equips military aircraft with NEXCOM radios. As users equip with the avionics needed for data communications, data services will migrate from VDL Mode-2 to NEXCOM, and new data link services will be provided directly by the FAA. NEXCOM radios operating in analog voice mode will continue to replace legacy radios in order to sustain the overall air-ground system.

Service provider networks are expected to accommodate new data communications applications in domestic and oceanic airspace. For oceanic communications, satellites will be used increasingly for new applications as the cost of satellite services declines. A transition to domestic air-ground satellite service is dependent on performance, equipage, and competitive pricing for service.

Figure 17-8 depicts an overview of the mobile communications system as it will appear in this time period.

17.1.3.2 Ground-Ground Mobile Communications

Agency ground-ground mobile communications are modest but widespread. The FAA uses a large number of pagers, portable telephones, and modem-equipped laptop computers. The latter are

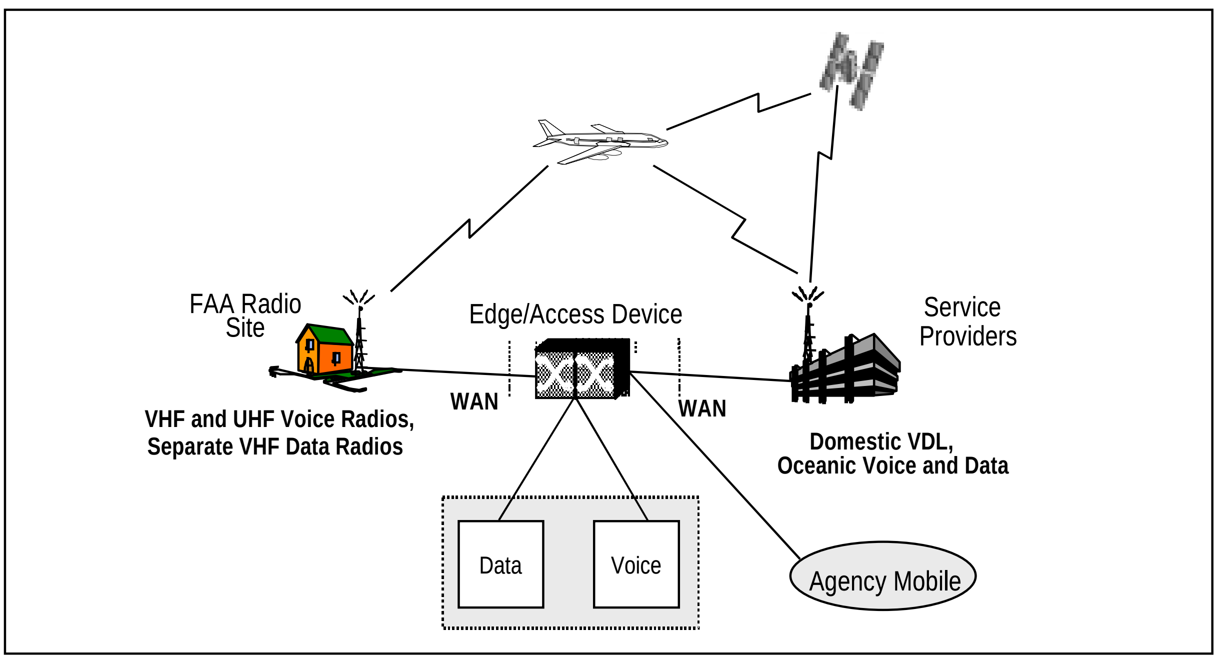

Figure 17-7. Mobile Communications Architecture in 2005

PART III

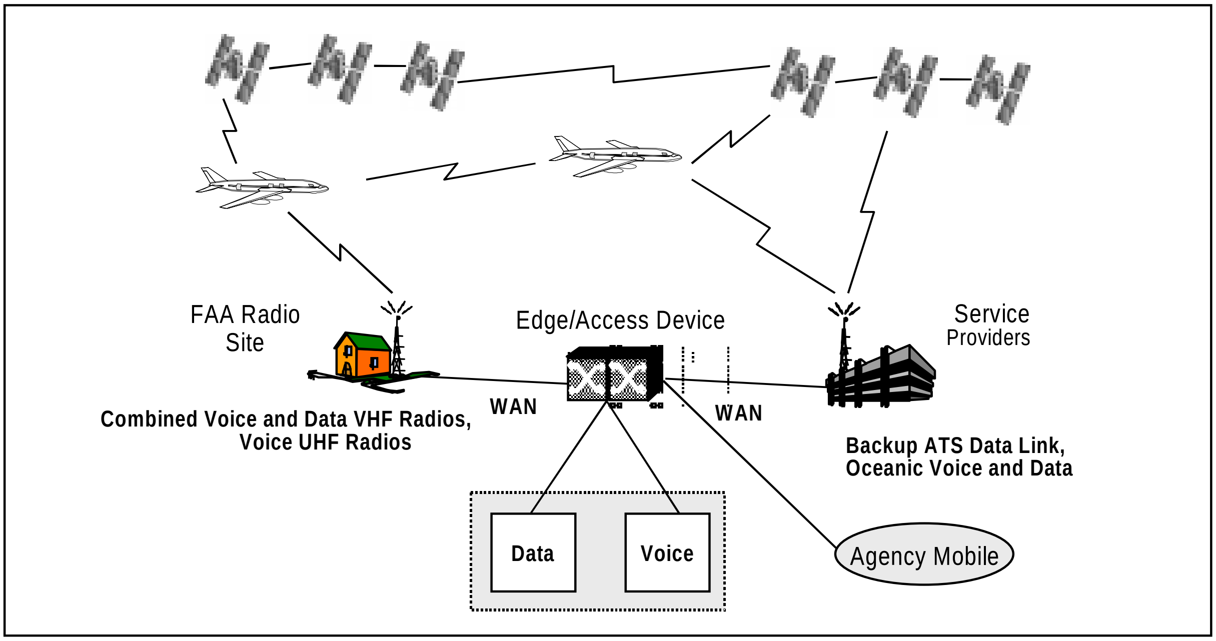

Figure 17-8. Mobile Communications Architecture in 2015

used to access data bases on departmental servers and to send and retrieve e-mail.

The present method of procuring mobile communications for maintenance and administrative use (e.g., pagers and mobile radios) is through the FTS 2000 contract. This same method will be used in the follow-on contract, FTS 2001.

17.1.3.3 Mobile Communications Schedule

The major events occurring during the mobile communications transition are shown in Figure 17-9.

17.1.4 Data Link Service

The purpose of data link applications is to facilitate exchange of ATC weather, flight service, and aeronautical information between aircraft and ground systems. Data link is expected to reduce congestion on voice channels; reduce misunderstanding of instructions and information; reduce the need for transcribing messages by air crews; reduce the workload of FAA ground personnel, such as air traffic controllers and flight service specialists; and facilitate CDM. The aviation user community—through forums such as RTCA Task Force 3 and the Free Flight Select Committee—has stated a firm need for data link in order to achieve operational benefits.

Data link includes the computer-human interface (CHI) for pilots and controllers, applications software in cockpit avionics and ground automation systems, the data link applications processor, and the communications infrastructure (air-ground, airborne, and ground communication systems). The previous section, 17.1.3, describes the air-ground transmission system that will be used for data link. This section, along with the automation sections, describes the applications software. See Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing; Section 20, Traffic Flow Management; Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; Section 24, Tower and Airport Surface; Section 25, Flight Services; and Section 26, Aviation Weather.

A number of data link applications will use ATN to provide global, seamless, secure, and error-free communications between air- and ground-based systems. ATN will use multiple subnetworks (i.e., VDL, HFDL, and SATCOM) to provide this service.

17.1.4.1 Data Link Service Description

Data link services will be implemented in stages to facilitate phased delivery of user benefits. The stages also allow familiarization with the new technology and orderly integration with the NAS

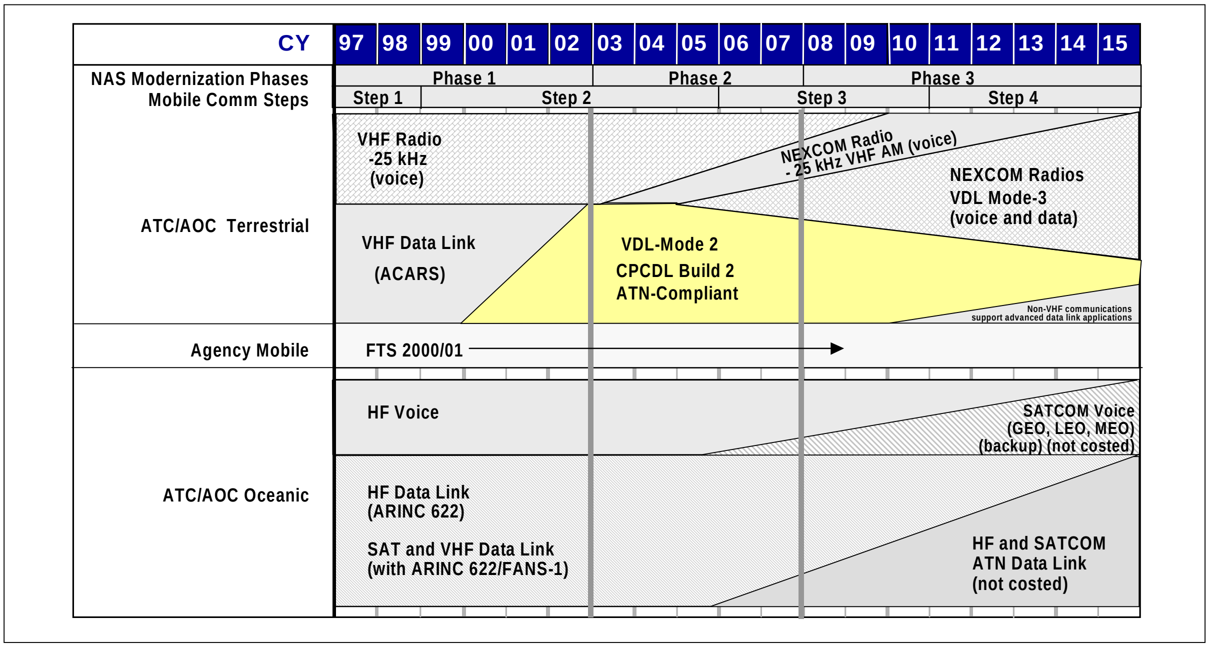

Figure 17-9. Mobile Communications Transition

telecommunications and automation infrastructures. Initial services will provide a foundation for more advanced services and will evolve from computer-to-human information transfer to include computer-to-computer information transfer.

Data link will provide three major evolutionary capabilities:

- Services that support communications between pilots and controllers
- Ground-based services that provide relevant information to pilots
- Decision support services that support coordination among flight decks, airline operations centers (AOCs), and air traffic management services for efficient flight management.

The data link section discusses services in the following order:

- Controller-Pilot Communications and Air Traffic Services:
  - – Tower Data Link Services (TDLS)
  - – Data Delivery of Taxi Clearance (DDTC)
  - – Controller-Pilot Data Link Communications (CPDLC)
  - – Oceanic Two-Way Data Link Communications (TWDL) Services
- Flight Information Services:
  - – Flight Information Service (FIS)
  - – Meteorological Data Collection and Reporting System (MDCRS)
  - – Terminal Weather Information for Pilots (TWIP)
  - – Traffic Information Service (TIS)
- Decision Support System (DSS) Services.

17.1.4.1.1 Controller-Pilot Communications and Air Traffic Service

CPDLC is a means to provide ATS data services, which are currently voice-oriented, and to transition some of these services to data link. The earliest stage of data link is currently in operation and supports communications such as predeparture clearances (PDCs) and digital automated terminal information services (D-ATIS). A data delivery of taxi clearance service is being tested as a prototype capability at the Detroit Tower. In oceanic airspace, FANS-1/A-equipped aircraft use data link service via SATCOM to exchange all types of ATC messages, including automatic dependent surveillance addressed (ADS-A).

Tower Data Link Service. The TDLS system automates tower-generated information for transmission to aircraft via data link. TDLS interfaces with sources of local weather data and flight data and provides PDC and D-ATIS. PDC helps tower clearance delivery specialists compose and deliver departure clearances. The clearances are then transmitted in text form via the Aircraft Communication and Reporting System (ACARS) to an ACARS-equipped aircraft for review and acknowledgment by the flight crew. The D-ATIS application also enables controllers to formulate D-ATIS text messages for delivery. The ATIS text messages are then delivered to flight crews via ACARS data link. An ATIS automatic voice-generation function produces spoken broadcasts using a synthesized voice to read the ATIS message.

Data Delivery of Taxi Clearance. DDTC is being implemented as a prototype capability at the Detroit Tower for operational assessment by the FAA. DDTC, like PDC, reduces both the delay in communicating the clearance information as well as any inaccuracies inherent in voice communications. The DDTC service will also use ACARS and, based on results, may be expanded to other TDLS locations.

Controller-Pilot Data Link Communication. CPDLC will be implemented first in the en route environment in a four-step process to introduce early benefits to NAS users while minimizing technical and procedural risks during development of the ATN-compliant system. Each of these steps is associated with specific automation software development and implementation activities (e.g., host computer software releases, DSR implementation and upgrades, and data link applications processor (DLAP) implementation).

Oceanic Two-Way Data Link Service. FANS-1/A avionics enables Boeing and Airbus aircraft to conduct TWDL. FANS-1/A-equipped aircraft will have automatic dependent surveillance (ADS) capability in FAA-controlled Pacific Ocean airspace. Oceanic data link services will evolve to ICAO-ATN-compliant communication services and applications over an extended transition period of accommodation for both FANS-1/A- and ATN-equipped users.

17.1.4.1.2 Flight Information Services

Flight Information Service. FIS will be provided to the cockpit by data link in the future. FIS information is defined as noncontrol advisory information needed by pilots to operate more safely and efficiently in both domestic and international airspace. FIS includes information necessary for continued safe flight and for flight planning, whether in the air or on the ground.

The rationale for providing FIS to the cockpit via data link is to improve safety, increase NAS utility, efficiency, and capacity and reduce costs to the user and the FAA. FIS is intended to complement, not replace, existing voice communications. Initial FIS products for delivery to the cockpit include information on NAS status (e.g., notices to airmen (NOTAMs) and special use airspace (SUA)) and meteorological information in text and graphic formats.

FIS depends on both public and private enterprise to provide affordable FIS products. To ensure services are developed and provided to the cockpit, the FAA will use private sector FIS wherever possible to bring services and products to the marketplace quickly and efficiently. The FAA will make NAS status and existing weather data available to private data link service providers for the development of FIS products. Commercial providers may make basic FIS products available, at no cost to the government or the user, and may make “value-added” products available for a fee. Such products are likely to include graphical/textual weather dissemination, first as a broadcast service, then as request-reply. Enhanced FIS, the final system, is likely to offer a mix of both government- and private sector-provided services.

Meteorological Data Collection and Reporting System. A number of today’s aircraft measure wind, temperature, humidity, and turbulence information in-flight and automatically relay the information to a commercial service provider. The service provider collects and reformats the information into MDCRS format and forwards it to the National Weather Service (NWS). The NWS uses this information and weather data from other sources to generate gridded weather forecasts. The forecasts are distributed to airlines and the FAA to help plan flight operations. The NWS gridded weather forecasts generated based on MDCRS will also be provided to WARP for use by meteorologists and to be forwarded to other automation systems and tools, such as the User Request Evaluation Tool (URET). ITWS will combine MDCRS with other terminal area weather information to create a high temporal, high horizontal resolution (5 minute/2 km) terminal area wind forecast.

Terminal Weather Information for Pilots. TWIP uses information from the terminal Doppler weather radar (TDWR) to provide near real-time aviation-tailored airport windshear and micro-burst information to pilots in the form of text and character graphic messages over ACARS. The future transition of TWIP to ITWS will improve the accuracy of weather information to the cockpit. TWIP functionality will be incorporated into the airport surveillance radar-weather system processor (ASR-WSP) system, thereby extending windshear coverage. By expanding the choices of delivery mechanisms, it may be possible to extend this capability to a broader community of users.

Traffic Information Service. The TIS application is being fielded currently at 119 sites nationwide. Using the Mode-S data link, a TIS ground processor uplinks surveillance information generated by a Mode-S sensor to properly equipped aircraft. The aircraft TIS processor receives the data and displays the data on the TIS display, providing increased situational awareness and an enhanced “see-and-avoid” capability for pilots.

17.1.4.1.3 Decision Support System Services

The most advanced set of capabilities will come from the interaction of air and ground DSSs. These expanded data link services are required to integrate flight deck systems, such as flight management systems (FMSs) with advanced ATM capabilities. The automated downlink of information, such as aircraft position, velocity, intent, and performance data from flight management systems to ground-based DSSs, will improve trajectory prediction and increase the accuracy of these systems.

17.1.4.2 Data Link Service Evolution (2000–2008 and Beyond)

Initial data link services only involve information to aircraft and require no reply from the flight deck. The next stage of evolution adds controller-pilot dialogue capability to communicate strategic and tactical air traffic services messages that are currently conveyed by voice. This will be augmented with request-reply functionality, which is initiated by the flight deck. In this case, a ground-based processor receives a downlinked request from the flight deck, compiles the requested information, and uplinks it to the aircraft for display. Next, data link will facilitate an automated downlink of weather and aircraft state-and-intent information to improve the prediction capabilities of decision support and weather systems. Finally, data link will facilitate a more extensive use of user-preferred trajectories through the negotiation of conflict-free trajectories between the flight deck and ATC service providers.

Data Link Architecture Evolution

Step 1 (1999-2002). CPDLC Build 1 will introduce an initial ATN-compliant CPDLC data link capability at one key site—the Miami ARTCC—for four selected messages over the VDL Mode-2 network. Four selected message types are potential candidates for this: transfer of communications (TOC), initial contact (IC), altimeter setting message (ASM), and predefined messages (PDM). The TOC will be the first message type to be tested. This leverages planned avionics upgrades by the airlines to equip with VDL Mode-2 for AOC communications and to participate in ATN data link trials in Europe. This approach should ensure a reasonable population of suitably equipped aircraft for initial operation and evaluation. This key site evaluation will determine operational utility and whether users benefits are sufficient to warrant further development. It will mitigate risks by deploying an operational tool to evaluate system performance, training procedures, and human factors requirements and solutions.

A multisector oceanic data link (ODL) that uses satellite communications is being installed to provide a reliable data communications link between pilots and controllers for FANS-1/A-equipped aircraft. This data communications consists of internationally standardized CPDLC messages for routine air traffic control and free text messages (see Section 22, Oceanic and Offshore).

Initial flight information services, such as weather to the cockpit, are currently available via a service provider. TIS, via Mode-S data link, are being fielded at selected sites nationwide.

Step 2 (2002-2004). CPDLC Build 1A expands the message set from 4 to 18 operational messages, including pilot-initiated downlink messages. This build will continue to use VDL Mode-2 technology. Minor changes to the en route automation system (i.e., Host/oceanic computer system replacement (HOCSR)) and DLAP are required, but no upgrades are needed for the avionics. Expansion will take place center by center to ensure an orderly transition to nationwide implementation. Throughout this process, the results of the U.S and EUROCONTROL projects will be used to refine the cockpit and controller human factors and refine the message set for CPDLC Build 2; this will provide a set of messages with the most value to pilots and controllers.

During this time frame, ADS-A will provide surveillance of intercontinental flights in oceanic airspace through satellite data link. ADS-A will allow automated position reports and intent information to be periodically sent from the aircraft FMS to ground controllers via data link. This represents a significant improvement over manual voice reporting. The ground controller establishes the frequency of reports with the FMS and sets the event threshold for conformance monitoring. The FMS automatically transmits any deviations from assigned altitude or course. Additional information is included in Section 22, Oceanic and Offshore.

Step 3 (2004-2006). CPDLC Build 2 via VDL Mode-2 expands the message set from 18 to more than 100 operational messages. DSR will require changes to make the CHI suitable for the expanded message set. En route automation changes will also be required.

Step 4 (2007–2015). CPDLC Build 2 will transition from VDL Mode-2 to the FAA-owned NEXCOM air-ground communication network that uses VDL Mode-3 technology. VDL Mode-2 will continue to be available via a service provider for AOC use. Later in the step, CPDLC Build 3 will be implemented over the NEXCOM air-ground communications network. Build 3 will provide the full ICAO-ATN-compliant message set for both the en route and the high-density terminal domains. Compared to VDL Mode-2, NEXCOM will have greater capacity and will provide message prioritization that meets operational requirements associated with the full ATN-compliant message set. NEXCOM will also satisfy communications performance requirements needed for decision support services.

NAS-wide data link services will be available from a combination of service providers and the FAA. It will include the full CPDLC message set and expanded FIS and TIS.

17.2 Summary of Capabilities

Today's air-ground radio system was designed for analog voice but has been adapted to provide limited data exchange capability. Currently, predeparture clearances and D-ATIS are being provided at 57 airports using ACARS, a VHF service provider system operating at 2400 bps. The meteorological data collection and reporting system services also use ACARS, which transmits in-flight weather observations to the NWS. Taxi clearances over ACARS were demonstrated in 1997, and a nationwide implementation of this system is planned.

Selected non-time-critical CPDLC messages for transfer of control using ATN-compliant protocols over VDL-2 will be implemented first at a key site. Coverage will be expanded nationwide using a larger message set. NEXCOM will be introduced in three steps beginning with digital voice for en route communications, followed by en route data link communications and then expanding NEXCOM service to the busiest terminal areas. All aircraft with the exception of military aircraft will require NEXCOM radios to operate in selected airspace at that time.

FANS-1/A TWDL will become operational in 1998. HF voice, HFDL, and satellite communications will all be available in the oceanic environment for many years.

Figure 17-10 shows data link evolution beginning with existing operational and prototype services.

17.3 Transition

The key communications transitions appear in Figures 17-3, 17-6, and 17-9.

17.4 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment

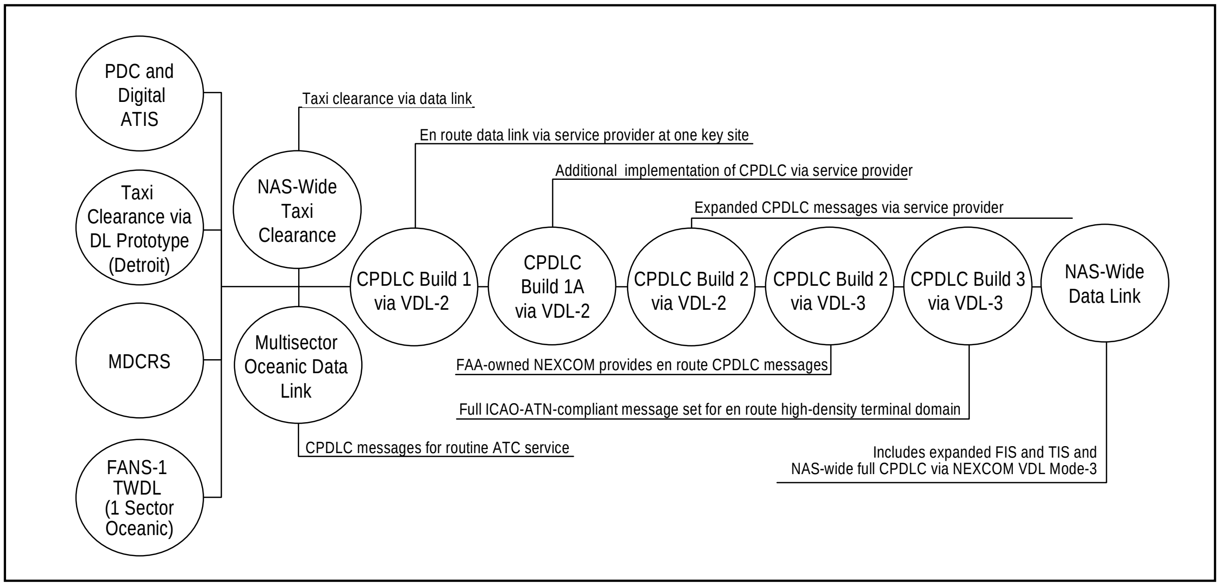

Figure 17-10. Data Link Services Capabilities Summary

(F&E); and operations (OPS) life-cycle costs for the communications and data link architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 17-11.

17.5 Watch Items

The most significant implementation factor in modernizing FAA communications and migrating to Free Flight will be the transition to NEXCOM radios and specification of minimum avionics equipage for all en route and high-density terminal areas. The FAA needs to work through appropriate government and industry forums to develop proposed rulemaking for NEXCOM equipage.

The cost for data link messages needs to be addressed so that the additional cost does not deter users from equipping with the avionics necessary to use the capability.

PART III

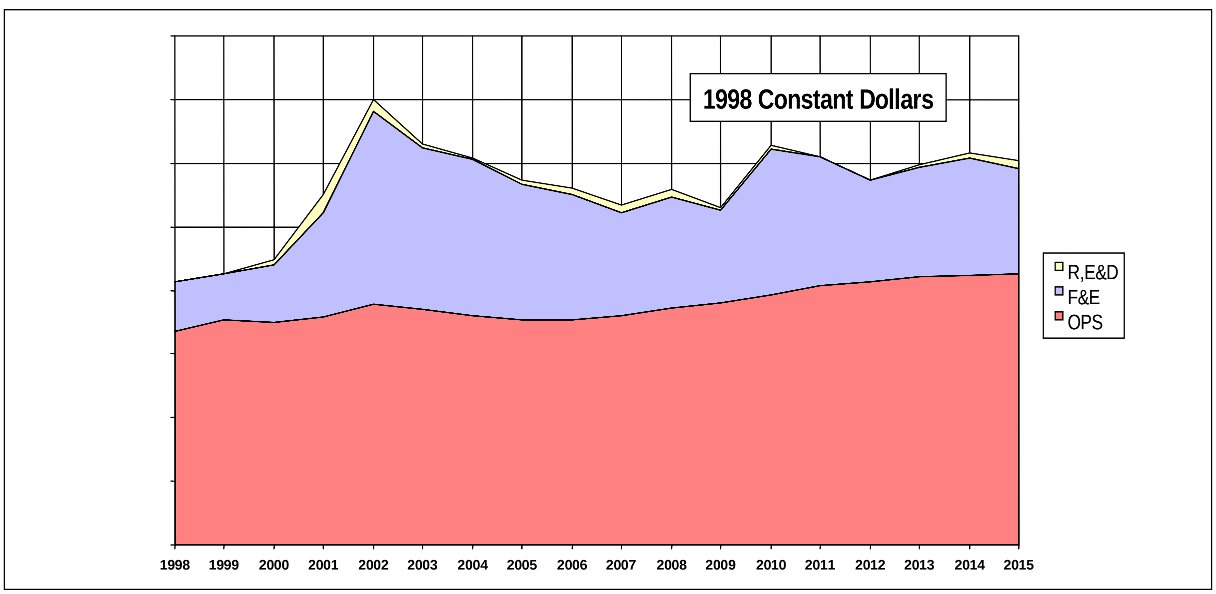

Figure 17-11. Estimated Interfacility Communications and Data Link Costs

18 AVIONICS

The most noticeable and rapid changes in aviation during the past 20 years have been in the avionics equipment available to all user classes, from small general aviation (GA) aircraft to large transport category aircraft. This will continue to be true in the future NAS because new capabilities and air traffic control (ATC) services will depend on avionics equipage. One factor the architecture reflects is the time required for the FAA to certify the new avionics envisioned for the future NAS.

The FAA is responsible for certifying new avionics to ensure the equipment meets acceptable performance and interoperability standards and operates safely. International agreements will be needed to enable worldwide manufacture and interoperability of avionics equipment. Another factor for the architecture is what, if any, changes in minimum avionics equipage requirements will be necessary for operating in the NAS and how to accommodate an aircraft fleet with mixed equipage levels.

Section 4, NAS Operations; Section 15, Navigation, Landing, and Lighting Systems; Section 16, Surveillance; and Section 17, Communications describe a variety of systems (or concepts that will lead to systems) for future NAS capabilities, some of which will require new avionics. New avionics may require new air traffic control procedures and/or aircraft operating procedures (14 CFR Part 91, 135, etc.) before the full benefits of the equipment can be realized.

Equipment (such as avionics) or modification to an aircraft must first be approved through the FAA's certification process. Although there are several ways to receive certification (such as Technical Standard Order Authorization, Supplemental Type Certificate, etc.), in general, each method leads to the same three required approvals: design approval, production approval, and installation approval. This is a very high-level representation of the comprehensive certification mechanism manufacturers must satisfy before installing products on an airplane.

Certification is not a standard process that occurs over a given period of time. Each product to be certified has a unique set of variables that affect the length of the certification process. The following time estimate for avionics certification is used for architecture planning purposes.

Industry collaboration to develop performance standards in a forum such as an RTCA Special Committee can take 2 to 3 years. Once a manufacturer applies for certification, FAA design and production approval can take up to 1 year, and installation approval can take another year. If rulemaking is necessary, it can take 3 to 4 years for a final rule to be issued. However, the rule development process can begin at any time (i.e., rulemaking is not tied to any manufacturer's product design, production, or installation approval). Architecture transition planning estimates account for aircraft equipment certification requirements and possible rulemaking actions (see Section 11, Regulation and Certification Activities Affected by New NAS Architecture Capabilities). RTCA has recently convened Task Force 4, an Industry/Government forum, to review FAA certification processes.

Traditionally, as the NAS evolved, questions about avionics equipage levels were addressed from the viewpoint of allowing user access to airspace while minimizing the equipage cost burdens consistent with safety. The architecture assumes the viewpoint that the benefits from new capabilities and services enabled by future avionics will provide the incentive for operators to equip. However, mixed avionics equipage levels will continue to be a fact of life in the future NAS.

The minimum equipage requirements/mixed equipage issue is complex due to diversity in operations (Part 91, 121, etc.), numerous aircraft types and performance levels, operational conditions (instrument or visual meteorological conditions), and the various airspace classes. Planning remains to be done on the mixed equipage issue to decide what, if any, new avionics minimum equipage requirements or changes in flight procedures will be needed. Therefore, the avionics architecture evolution steps, schedule charts, and cost charts described in this section *do not represent minimum equipage requirements for operating in the future NAS.*[1]

1. Terrain Alert and Warning System (TAWS) is an exception. See Step 1, cockpit displays page 18-4.

PART III

18.1 Avionics Architecture Evolution

The avionics architecture evolution steps estimate the time periods when avionics should be available to support the capabilities described in the communications, navigation, and surveillance sections.

18.1.1 Avionics Architecture Evolution—Step 1 (Current–1998)

Navigation

Aircraft avionics include a variety of navigation signal receivers such as very high frequency omnidirectional range (VOR), distance measuring equipment (DME), nondirectional beacon (NDB), tactical air navigation (TACAN), instrument landing systems (ILS), Long Range Navigation-C System (Loran-C), and the Global Positioning System (GPS) (either visual flight rules (VFR)-only or Technical Standing Order (TSO)-C-129-compliant). These receivers, which are built to international standards, are compatible with the NAS navigational aids infrastructure. Avionics receivers are usually installed in aircraft in various combinations to provide navigation, nonprecision, and precision instrument approach guidance to pilots, using signals from receivers displayed on various flight instruments and displays.

More sophisticated aircraft are equipped with flight management systems that process information from the receivers to provide area navigation capability, although GPS is making area navigation more readily available to low-end users as well.

From an avionics-equipage perspective, there are few problems with the current navigational receivers other than the number that must be installed for navigation. Equipment is affordable, reliable, and internationally interoperable. In some terminal airspace, there is potential interference from frequency modulation (FM) broadcast signals with localizer signals. Additionally, ILS installation costs and problems in obtaining a suitable frequency limit the number of airports that can have precision approaches.

Surveillance

Most aircraft that use NAS and ATC services are equipped with highly reliable and affordable transponders. In general, aircraft are not permitted to fly above 10,000 feet or in certain terminal airspace unless they are transponder-equipped. When interrogated by a secondary surveillance radar (SSR), aircraft transponders reply with the aircraft’s altitude and assigned identification code, which is then displayed on controller workstations. Transponders also respond to interrogations from airborne traffic alert and collision avoidance systems (TCAS). TCAS I includes a pilot display that identifies the location and relative altitude of nearby transponder-equipped aircraft. Aircraft equipped with TCAS II also provide pilots with a vertical resolution advisory to prevent mid-air collisions. Most domestic passenger-carrying airplanes with 10 to 30 passenger seats are required to have TCAS I; airplanes with more than 30 passenger seats must have TCAS II.

Communications

In the domestic environment, pilots and air traffic controllers use very high frequency (VHF) amplitude modulation (AM) radios for communicating and receiving air traffic control service information and in-flight weather information. Department of Defense (DOD) aircraft use both VHF and ultra high frequency (UHF) radios for air traffic control services. The FAA also uses the VHF spectrum to broadcast either recorded or automated weather observations of airfield conditions.

All aviation safety communications services for the U.S. oceanic regions use high frequency (HF) voice communications via a commercial service provider. The airlines also use ARINC’s HF Data Link services or FANS-1/A-compliant equipment for data link services on transoceanic flights.

Some difficulties and limitations associated with communications in the NAS were identified in Section 17. Due to the growth in aviation activity, voice channel congestion is occurring. In some locations, the VHF spectrum is saturated to the point that no additional channels are available to expand existing ATC services or accommodate new services, such as the Automated Terminal Information Service (ATIS), or automated weather observations. Spectrum availability is one of the critical limiting factors to expanding NAS services and meeting growing demand.

Users, particularly the GA segment, have expressed a desire for a new universal data link communications capability to receive flight information services (FIS), such as updated weather forecasts, hazardous weather advisories, and/or graphical weather depictions in the cockpit. Commercially provided FIS services that include electronic messaging as well as weather information are becoming available for low-end GA users. Traffic Information Service (TIS) via Mode-S using the 1030/1090 MHz spectrum is addressed in Sections 16 and 17.

Cockpit Displays

Aircraft with electronic flight information systems (EFIS) can display a variety of information, such as navigation routes, onboard weather radar data, and TCAS information. EFIS displays are currently used to replace analog gauges with digital multifunction electronic displays; however, their functionality remains similar to that of the analog gauges they replace. Initial displays with limited multifunction capabilities are also available to low-end GA users.

One primary concern for all aircraft is the limited amount of panel space available for avionics and displays. This highlights the need for integrated avionics equipment and displays, which will take up less space than today's piecemeal, stand-alone systems. Integrated avionics suites are more prevalent on air carrier and high-end GA aircraft with EFIS displays and flight management systems. However, even these aircraft have problems resulting from add-on stand-alone equipment, and not all air carrier or corporate aircraft have EFIS displays or flight management systems.

During Step 1, terrain awareness capability is available for air carriers and high-end GA aircraft through ground proximity warning systems (GPWS) that provide aural warnings when an aircraft is close to the ground. An enhanced terrain awareness warning system (i.e., the terrain alert and warning system (TAWS)) that provides more warning time than GPWS is becoming available. TAWS uses position data from a navigation system, such as a flight management system (FMS) or GPS, and input from a digital terrain data base to display surrounding terrain. The computer sends warning alerts to the plane's audio system and displays in the event of a potential collision with terrain. The TAWS computer can input display data to either the weather radar, EFIS, or some other display screen on which the surrounding terrain is shown with the threatening terrain highlighted.

Currently, some air carriers are voluntarily equipping with TAWS, and the FAA has released a notice of proposed rulemaking to mandate TAWS equipage. During Step 2, the FAA will mandate TAWS equipage to replace GPWS as the standard terrain warning system. TAWS will be required on all U.S.-registered turbine-powered airplanes with six or more passenger seats.

18.1.2 Avionics Architecture Evolution—Step 2 (1999–2003)

Safe Flight 21, a limited operational demonstration, will be a key step toward mitigating the scheduling and technological risks associated with NAS modernization. Safe Flight 21 is important to the avionics architecture evolution because the safety and efficiency benefits of modernization outlined in the overall architecture depend largely on avionics. The Safe Flight 21 program will test the avionics and ground infrastructure as a whole. Results from the Safe Flight 21 program will be used to refine the architecture, including avionics evolution. See Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone, for a more complete discussion of the Safe Flight 21 program.

Navigation

In Step 2, GPS avionics capabilities will have at least three distinct levels of sophistication: (1) a GPS receiver for en route navigation and nonprecision approach capability; (2) a GPS Wide Area Augmentation System (WAAS) receiver with precision approach capability (Category (CAT I); and (3) a GPS Local Area Augmentation System (LAAS) receiver with CAT I/II/III precision approach capability. WAAS and LAAS are designed to provide a level of service equivalent to or better than ground-based systems. The architecture supports dual operations, from WAAS initial operating capability (IOC) until the ground-based navigation system phase-down is complete. This provides ample time for users to transition to GPS avionics and for the FAA to ensure that augmented GPS (WAAS/LAAS) operates as designed.

During this time frame, traditional ground-based navigation aids will continue to be available and studies will be completed to determine what, if any, ground-based navigation aids should be retained to supplement augmented GPS. If unforeseen problems arise, the architecture will be adjusted and phase-down of ground-based navigation aids will be appropriately modified. The FAA will not transition entirely away from ground-based navigation aids until it is certain that augmented GPS meets required performance. DOD will conduct an analysis to determine what GPS avionics capability is suited to its worldwide military mission, as well as to the NAS.

When purchasing equipment, all instrument flight rules (IFR) users will have to consider the cost of GPS navigation data base updates. IFR GPS navigation data bases must be updated every 28 days to match the cycle for chart and approach plate updates that reflect navigation/approach changes in the NAS. Currently, the cost to update low-end GA GPS navigation data bases is $500 to $700 per year.

Surveillance

Air-air automatic dependent surveillance broadcast (ADS-B), using GPS as the primary source of navigation data, will be available for pilot situational awareness. ADS reports will include aircraft identity, position, velocity vector, and other essential information. ADS-B-equipped aircraft within the proximity of another ADS-B-equipped aircraft can receive the broadcast, decode the position data, and display the received position on a cockpit display. Air-air ADS-B will require special avionics, GPS or FMS area navigation capability, and a cockpit display, including interfaces for the various components. Broader application for ATC surveillance will depend on creating an ADS ground infrastructure.

In Step 2, TCAS remains as an independent air-air collision avoidance system. ADS-B avionics will operate on a noninterference basis with TCAS-only-equipped aircraft. During this step, the existing equipage requirements for transponders and TCAS will remain in place and no change will be required for TCAS software, due to ADS-B. Also, Mode-3/C transponders will still be in use, operating seamlessly in the same system.

In the oceanic environment, the FAA will begin installing the necessary infrastructure to support automatic dependent surveillance addressable (ADS-A) operations. The main incentive for users to equip with ADS-A avionics will be access to selected oceanic tracks that permit more optimum flight profiles. Additionally, air-air ADS-B avionics will be used to support in-trail climbs/descents in the current oceanic track system.

Communications

In collaboration with industry, the FAA will finalize standards for next-generation communications system (NEXCOM) VHF digital link (VDL-Mode-3) radios that have digital voice and data capability. VDL-Mode-2 digital data services through a commercial service provider will be available to properly equipped users during this time frame. The current VHF (and UHF for DOD) amplitude modulation system will remain in use for voice communications. FIS services will continue to be available through commercial service providers.

During Step 2, HF voice and data link will continue to be the primary communication links in the oceanic area. However, voice and data communications via geostationary (GEO) satellites will become more prevalent because satellite communications will be the primary link for ADS-A capabilities.

Cockpit Displays

New cockpit display avionics will provide information to the pilot in textual and graphical format including ATC clearances and messages, traffic information, moving maps, terrain displays, weather, aircraft and flight monitoring, and other information. These capabilities will offer improved flight safety, efficiency, and flexibility, particularly for GA users. A flight computer is usually required to process the information and drive the displays. Sophisticated transport aircraft and business jets will begin the transition to text and graphic displays using their EFIS systems and initial air-air ADS-B and VDL-2 data link capabilities.

The Safe Flight 21 program will provide the operational testing environment for developing integrated cockpit displays and multifunctional avionics, particularly for low-end GA. The results will be used by the FAA to create appropriate standards for cockpit displays in all user categories consistent with the concepts in the NAS architecture.

18.1.3 Avionics Architecture Evolution—Step 3 (2004–2007)

Navigation

The transition to GPS-based avionics for navigation will continue in Step 3. Traditional ground-based navigation systems will remain in service but will begin phase-down. The FAA projects that by the end of Step 3 or in early Step 4:

- GPS WAAS avionics will be installed in 65 percent of the GA fleet and 100 percent of the GA business and air taxi fleets.
- 100 percent of the air carrier, regional, and commuter fleets will equip with a GPS WAAS/LAAS receiver.

DOD avionics may be based on the precise positioning service (PPS) signal available only to the military and authorized users, rather than on WAAS. During Step 3, DOD will start to equip its fleet (approximately 16,000 aircraft) with GPS avionics suitable for the NAS.

Surveillance

During Step 3, the FAA will begin installing ADS ground stations in nonradar en route areas and at major airports to use ADS-B for air-ground and airport surface surveillance. Aircraft with ADS-B avionics will provide a periodic broadcast of the aircraft's position, velocity, altitude, identification, and other information. Mode-3/C transponders will still be compatible with the NAS radar surveillance infrastructure.

TCAS will be retained as an independent collision avoidance system and the equipage requirements for TCAS and transponders will remain in place. ADS-B will be complementary to TCAS, but will not require software changes or replacement of TCAS equipment. The proliferation of air-air surveillance systems will enable broader application of pilot self-separation procedures and rules.

In the oceanic environment ADS-A and air-air ADS-B avionics will be used, along with navigation, ATC communications, and automation improvements, to reduce aircraft separation.

Communications

The FAA will begin replacing approximately 40,000 VHF radios with new digital NEXCOM radios that have both digital voice and data capabilities. The radios will be able to emulate the existing analog system and can be designed so that selected modulation techniques are software programmable. A phased transition to NEXCOM avionics will begin during Step 3 to provide VDL-Mode-3 service to users in the super high and high en route sectors (above flight level (FL) 240).

The FAA is considering mandating NEXCOM equipage for operators in these en route sectors during Step 3 because the transition depends on all aircraft in the airspace being equipped with a suitable digital radio. DOD will be exempt from any NEXCOM mandates and will continue using UHF for voice communications. Other en route sectors and terminal areas will continue to use VHF analog voice communications or NEXCOM radios in analog emulation mode. Users will be motivated to equip with digital radios mainly because of the reduced operational constraints from frequency congestion.

Cockpit Displays

New multifunctional displays will continue entering service at all levels to integrate data and information from systems such as TIS, FIS, ADS-B, GPS, etc.

18.1.4 Avionics Architecture Evolution—Step 4 (2008–2015)

Navigation

The architecture assumes that IFR users will complete their transition to GPS-based avionics during this time period. This will allow the FAA to complete the phase-down for traditional ground-based navigation systems, but some may remain in service if navigational system redundancy is warranted. GPS equipage will depend on user evaluation of operational need and any minimum equipage requirements the FAA may mandate. Those that fly VFR only will continue to do so and will either not have GPS at all or will equip with a noncertified VFR-only unit. Those that fly IFR down to CAT I precision approaches will equip with WAAS avionics or continue to use current TSO C-129 equipment and accept the nonprecision approach limitation. Those that currently fly to CAT II/III minimums will equip with LAAS.

Surveillance

Installation of ADS ground systems will be completed in the terminal and en route airspace, thus extending use of ADS-B for air-ground and airport surface surveillance. Aircraft equipped with TCAS and Mode-3/C transponders will still be compatible with the NAS infrastructure. ADS-B will be integrated with the future emergency locator transmitter (ELT) to provide discrete identification codes and GPS-based position information to enhance search and rescue operations.

TCAS will remain as an independent collision avoidance system, but the FAA may accept air-air ADS-B as an alternate means of complying with the collision avoidance mandate. The alternate compliance finding will depend on collecting data that prove air-air ADS-B is no less capable than TCAS. This data collection may be done during the Safe Flight 21 program. Additionally, implementing a TSO and changing existing regulations will have to be accomplished before air-air ADS-B can be substituted for TCAS.

Communications

As the transition to NEXCOM progresses, more ATC sectors will convert to digital communications, commensurate with user equipage. Flight information services such as weather information and notices to airmen (NOTAMs) will be available via the NEXCOM data link. During this step, the FAA is considering mandating NEXCOM radios at FL 240 and above as well as in selected high-density terminal airspace and some associated low-altitude en route sectors. Low-density terminal areas and en route sectors below FL 240 will continue using NEXCOM radios operated in analog emulation mode. DOD will be exempt from any mandated requirements and continue using UHF for air traffic services to allow more time to equip its significantly larger fleet.

Low and medium earth-orbiting (LEO/MEO) satellite systems will become available as an alternate means of ADS-A-compliant voice and data link communications for oceanic areas. Users will have a wider selection of avionics options because GEO and HF voice and data link systems will remain in use as well. Cost versus flexibility to fly optimum tracks and profiles will be a determining factor in how users choose to equip.

18.2 Human Factors

NAS modernization will invoke or accommodate significant changes on flight decks, such as using multifunction displays that present information on the location of proximate aircraft, weather, terrain, and other flight information. Human factors activities will be required in the development of avionics standards and installation, training, and maintenance guidelines. These include:

- Developing human factors requirements and standards for avionics certification
- Establishing human factors installation guidelines for retrofitting advanced avionics into older aircraft
- Developing, implementing, and assessing human factors training requirements for pilots, controllers, and maintenance technicians
- Standardizing avionics displays among different manufacturers.

18.3 Transition

Figure 18-1 shows the ground infrastructure transition to support avionics equipage and the anticipated transition for cockpit displays.

18.4 Costs

Table 18-1 shows estimated avionics equipment costs separated into four user-categories. The air carrier category represents major, national, and regional airlines flying all-jet fleets in Part 121 passenger or cargo revenue service. The mid-range category represents commuter, air taxi, and corporate GA flying turboprop, jet, or large multi-engine piston aircraft under Part 91, 121, or 135 regulations. The low-range category represents small single- or twin-engine piston aircraft operated under Part 91 regulations. The military category represents the full range of DOD aircraft from helicopters to cargo transports.

However, the lines between categories are often blurred because of aircraft type, performance, or operational use, and some aircraft or operations do not fit neatly into the defined categories. For instance, the New Piper Malibu, which is a single-engine piston aircraft, has the performance to be used in a Part 135 air taxi or small corporate aircraft operation. Similarly, one model of the Boeing 737, which normally fits the air carrier category, is being marketed as a corporate aircraft to compete against other high-end business jets with similar performance.

Table 18-1 provides a range estimate of nonrecurring costs for avionics equipment only. The table does not include items such as installation, or recurring costs for training or data base updates. The figures in the table are an average compiled from representatives of the avionics manufacturing industry and the military. For equipment, such as GPS/LAAS or ADS-B, the price range is an educated guess or cost goal because there are still too many unknowns relative to performance and certification requirements. For avionics such as EFIS displays or GPS-receiver autonomous integrity monitoring (RAIM), the costs are well known and the price range is based on the wide variety of choices and feature/capability options available.

Another factor that can affect the nonrecurring unit cost is the trend toward integrating avionics equipment rather than building individual, standalone boxes. The trend is particularly prevalent in the air carrier and mid-range categories but is also starting to affect the low-range category as well. One reason for the higher cost of air carrier and mid-range avionics is the higher reliability and performance standards the equipment must meet. For example, avionics on air carrier and high-end GA aircraft are typically built with more redundancy than equipment for low-end GA. The military has additional specifications that increase cost, such as resistance to electromagnetic pulse, ruggedizing equipment for high G loads, secure anti-jam system requirements, etc. Future architecture efforts must focus on what, if any, mandatory equipage requirements will be needed and by when.

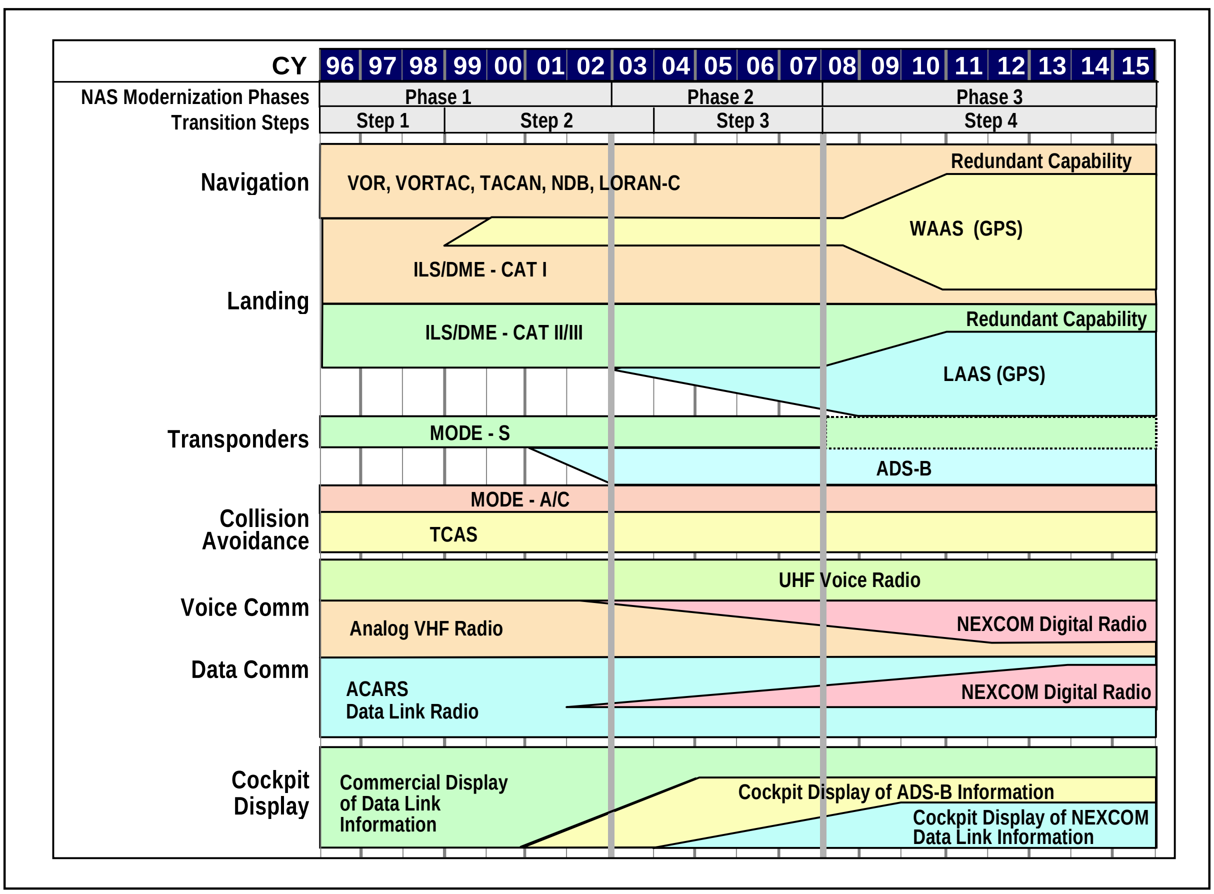

Figure 18-1. Ground Infrastructure Transition Supporting Avionics Equipage

Table 18-1. Estimated Avionics Costs (1998 Dollars)

Avionics	Air Carrier	Mid Range	Low Range	Military
Communication:				
Digital Radio (voice)	$10-20K	$10-20K	$4-5K	$60-80K[8]
CMU (data)	$25-45K[10]	$15-30K	$7-9K	$15-30K[12]
Cockpit Displays:				
TAWS	$47-50K[2]	$47-50K[1]	N/A[9]	$47-50K
EFIS	$200-229K	$40-229K[7]	N/A	$40-80K[13]
MFD	N/A	N/A	$10-12K[5]	N/A
FIS (Weather)			$6-8K[4]	N/A
Navigation:				
GPS-RAIM	N/A	$8-10K	$3.5-9K	$13-14K
GPS-WAAS	integ. with LAAS	$12-15K	$5-10K[3]	TBD
GPS-LAAS	$15-30K[11]	$15-30K[16]	N/A	TBD
Surveillance:				
ADS-A (Oceanic)	$700-775K[14]	$560-620K[15]	N/A	$800-1,000K[17]
ADS-B (Data Link)	$25-35K[20]	$25-35K	$5-7K[6]	$55-65K[18]
Mode-S	$20-30K[19]	$20-30K	$4.5-5.5K	$20-30K

1. Non-EFIS-equipped aircraft may have less capable system with regionalized data base and no reactive windshear costing between $15 and 20K.
2. For digital or analog data bus, includes reactive windshear. Requires EFIS display.
3. Additional costs may be incurred for annunciator lights or new course deviation indicator.
4. Includes dedicated display. Service available on laptop computer provided by operator for 1.5 to 2.0K.
5. Excluding equipment that provides information to display.
6. Includes basic Mode-S with ADS- B card and receiving/processing TIS information (no display). Predicts transponder cost decrease due to integrated functions and increased user equipage.
7. Price depends on how sophisticated/how many display tubes the EFIS has, i.e., a one-tube basic system versus a five- or six-tube high-end system.
8. Includes military-unique requirements such as secure communications capability.
9 Certified TAWS probably will not be available for small aircraft. However, noncertified TAWS-like capability will be available as part of MFD software packages.
10. Cost is dependent on several factors, such as range of features selected.
11. Cost presented here is an estimate for an integrated WAAS/LAAS receiver.
12. FAA will continue to support the UHF infrastructure for DOD use.
13. Costs vary depending on aircraft type and features selected.
14. Data from Industry Customization Working Group using B767 example. ADS-A is not sold as stand-alone equipment; it is part of FANS package, including display, FMC, CMU, etc., and hardware/software upgrades. Low figure is for FANS-1/A package without CPDLC capabilitiy and excluding GPS. High figure includes CPDLC capability. Add $260K for CNS/ATM-1-compliant package.
15. Industry Customization Working Group estimates that mid-range costs are approximately 15 to 20 percent less than air carrier costs. Add $220K for CNS/ATM-1-compliant package.
16. Cost for integrated WAAS/LAAS system similar to air carrier.
17. Complete FANS-1/A, CNS/ATM-1-compliant package, including displays, hardware, software, and military-unique requirements.
18. Includes TCAS II equipment with provisions for ADS-B add-on and military-unique requirements.
19. Airlines are required to have two transponders.
20. Mode-S with ADS-B card. Non-EFIS-equipped aircraft will also require a dedicated display costing approcimately $20K.

18.5 Watch Items

- Establish minimum equipage requirements with appropriate user input
- Review and implement RTCA Task Force 4 recommendations on certification.

19 NAS INFORMATION ARCHITECTURE AND SERVICES FOR COLLABORATION AND INFORMATION SHARING

The NAS information services offer a new collaborative capability for information sharing between FAA and NAS users and througout the FAA. Information sharing will be improved across all domains and with other organizations that need this information. Generating, processing, and distributing information is an integral part of the NAS. As emphasized in the Air Traffic Services (ATS) concept of operations (CONOPS), information exchange is essential to safe and efficient NAS operations.

The collaboration envisioned for the future is a complex process that is being jointly explored by the FAA and the user community. Collaboration and information-sharing services will evolve as experience is gained. Information exchange begins with data exchange as it now exists and then evolves to the collaborative process, as illustrated in Figure 19-1. The goal of an evolutionary approach is to begin collaboration as early as possible.

In the collaborative decisionmaking process, *users* make decisions associated with their operations (e.g., the priority of a particular flight leaving a location). *Service providers* make decisions associated with NAS resources (e.g., airspace and airport capacity during adverse weather conditions).

The NAS information services are based on consistent information exchange among NAS systems. These services, for the most part, are a result of system interoperability that is transparent to collaboration users and is provided through consistent interfaces developed for each system. To achieve interoperability, coordinated interfaces for data exchange among FAA and NAS user systems must be established during systems development.

Currently, NAS information is managed primarily within individual systems. Overall, this creates many inconsistent and inefficient local information management operations that are based on widely varying standards, definitions, and data structures. The future NAS information systems will make interoperability easier to achieve and more cost-effective. As the NAS grows more complex, system interoperability will become a necessity. Data standardization will support implementation of a common, flexible system with consistent interfaces between systems and which offers more options for the aviation community to share data with and retrieve data from the NAS.

19.1 Information Services Evolution

The NAS information services will be allocated, tailored, and integrated at three levels:

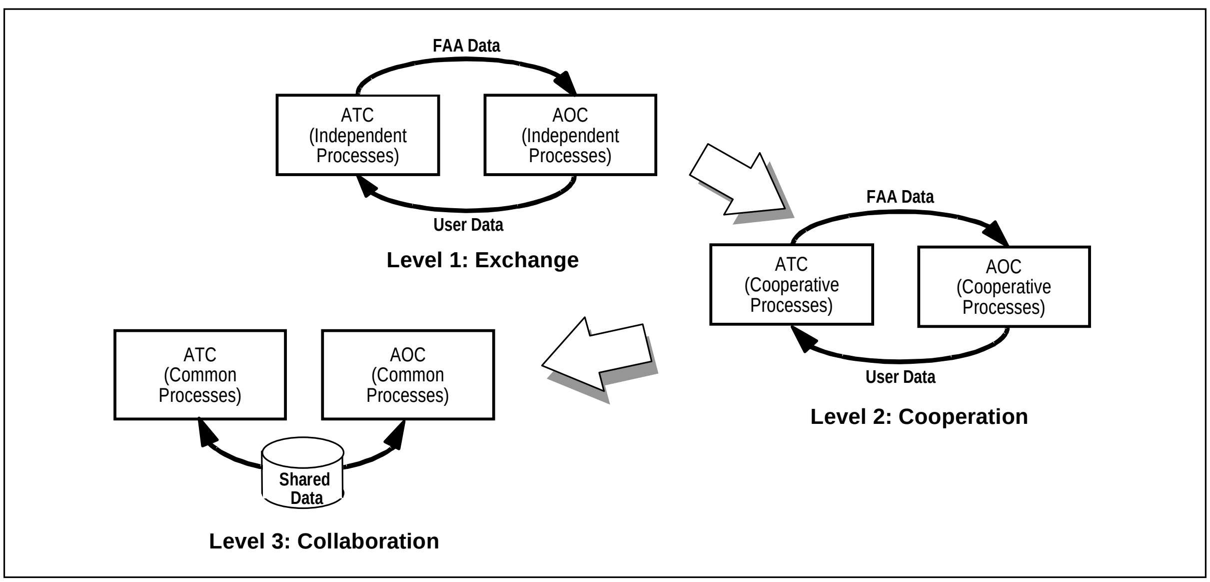

Figure 19-1. Evolution of Collaboration and Information Exchange

PART III

- Data standardization and interoperability across applications
- The local or facility levels
- The NAS-wide level.

Each of these will manage and maintain appropriate information for internal use and exchange with other users. Figure 19-2 shows the four major information end-user groups:

- FAA service providers
- Flight planners
- Aircrews
- Aviation auxiliary or indirect users.

A goal of NAS information services (in support of the CONOPS) is to share information seamlessly across these organizational boundaries; this requires data standardization.

Data Standardization and Interoperability

Data standardization will address how data are exchanged between multiple applications. For example, it will ensure compatibility between Center TRACON Automation System/Traffic Management Advisor (CTAS/TMA) applications and conflict probe (CP) applications within an en route center.

Data standards in existing systems are frequently inconsistent—sources for the same data may vary and formats may be incompatible. Interoperability requires translating data whenever information is transferred from one system to another.

Local- or Facility-Level Information Exchange

Local information systems will interoperate through consistently defined information exchange. As local legacy systems are replaced or new systems developed and deployed, commercial data base management systems will be used where applicable, and information models for all systems will be based on managed data standards.

Information exchange at the local or facility level will be the backbone of information exchange at the national level and with NAS users. Specific data categories—such as local weather data, adaptation data, dynamic and static resource data, flight and demand data, performance data and traffic management demand/capacity data—will be stored within the local information systems as required. The data will be updated and made

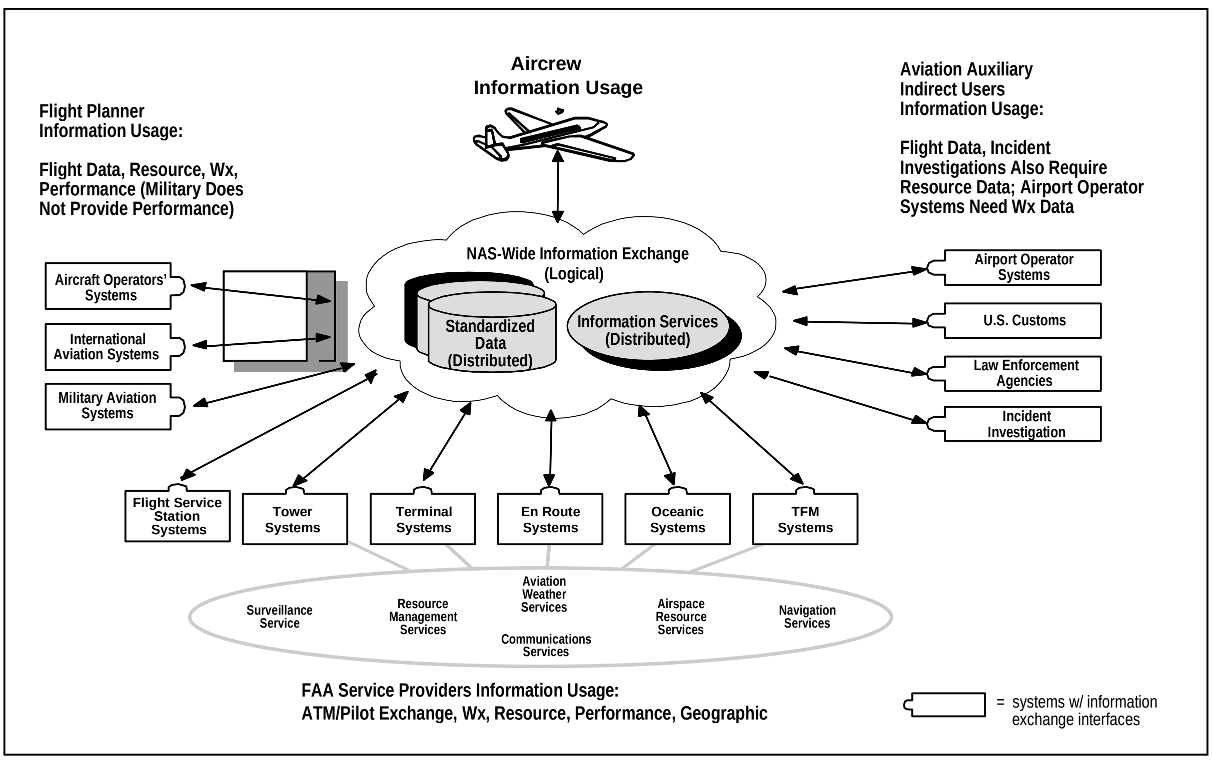

Figure 19-2. Seamless Information Flow in the NAS

available to NAS service providers and users as required.

NAS-Level Common Information Exchange

NAS-level common information systems exchange information across NAS facilities and among NAS service providers and NAS users. These interoperating systems require consistently defined information exchange. As these systems are replaced or new systems are developed, commercial data base management systems will be used where applicable, and information models for all systems will be based on managed data standards.

The standards will involve determining where data come from, who uses the data, how the data are defined, how the data are transformed, and who owns the data. The answers to these questions will help determine the data standards for specific items, such as the flight object (defined as flight plan information and other information, such as preferred runway and taxiway). It will include International Civil Aviation Organization (ICAO) flight-plan-compatible data and will be available to all authorized users, as defined during development of each system.

In some cases, such as for the aggregation and integration of airspace and airway adaptation data, no single authoritative NAS-level information system exists. Systems for such information services will be developed as NAS-wide resources.

The local and NAS-level common information exchange will evolve as depicted in Figure 19-3. These increments comprise a four-step evolution. The first step describes current information services. The second step establishes data standards (including definitions, sources, and formats) for achieving efficient interoperability among legacy systems (near-term view). The structured data can then be stored in external storage media, where the data will be directly accessible by external applications (mid-term view—Step 3). The target view (Step 4) represents the best in system interoperability in which information is easily and unambiguously exchanged as required. As it evolves, it will provide information to both users and service providers, taking into account necessary security precautions.

NAS Information Architecture

The exchange of information across the NAS envisioned by the CONOPS will be based on accepted industrywide information architecture principles.

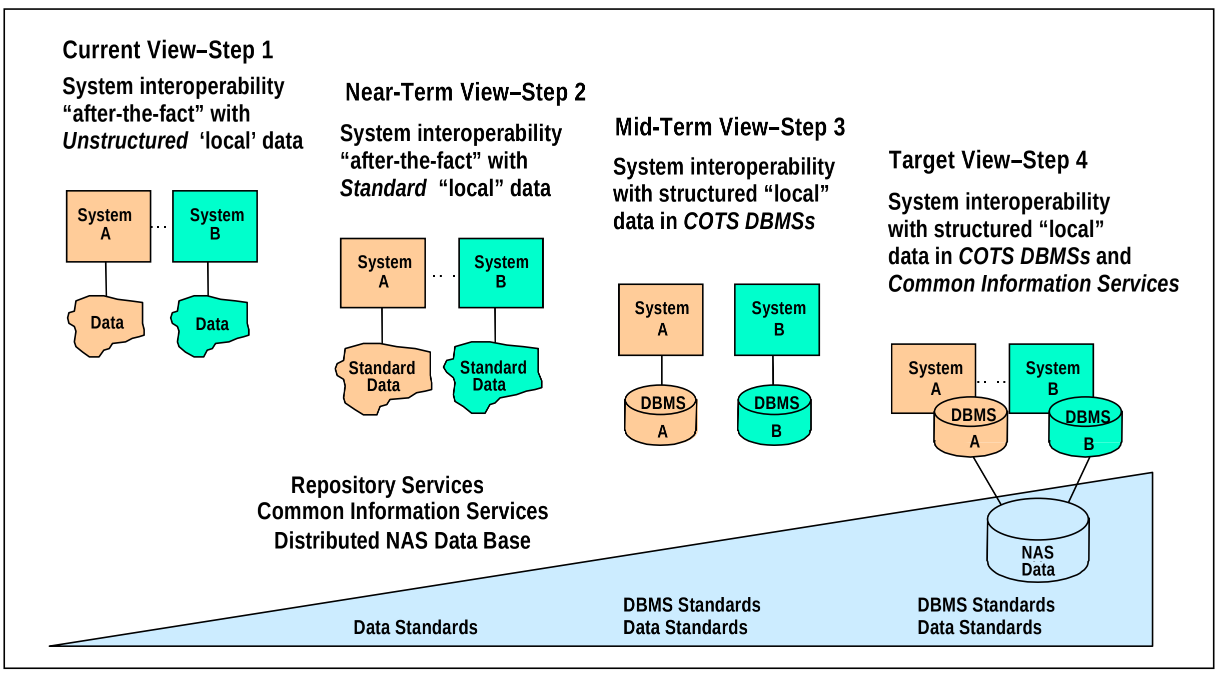

Figure 19-3. Evolution From Existing Information Systems to Future Systems

NAS Information Architecture Goals

The development of the information exchange in the NAS is based on meeting the following four goals:

- *Data Quality and Access:* Supporting the information needs of the many NAS users and service providers with timely, accurate, and complete information via system-to-system, human-to-system, and human-to-human information access
- *Interoperability:* Providing for data exchange, cooperation, and collaboration using data commonly defined by numerous NAS organizations, systems, and users
- *Cost-Effectiveness:* Delivering information in a cost-effective manner and emphasizing information reuse
- *Responsiveness, Flexibility, and Scaleability:* Responding to new functional needs quickly and efficiently.

Local- and NAS-level common information exchange systems will provide information services to foster convenient, widespread, standards-based information exchange supporting both collaborative and better-informed decisionmaking by NAS users and service providers. These systems will manage all types of NAS data, with emphasis on the core types of operational data (i.e., flight, surveillance (positions), NAS resources, and weather data). Both static (i.e., descriptive) and dynamic (i.e., NAS status) data will be managed, and operational data will be used for real-time safety and traffic flow decisionmaking, as well as for pre- and post-event analysis to improve operational performance.

To support data exchange as envisioned, local- and NAS-level information systems will be implemented using a variety of information technologies and tools, including information standards, services, and processes. More importantly, new information management processes will be put in place to achieve coordination across organizations, domains, and systems.

The information exchange will be service-oriented. To be successful, it requires systems that cannot be specified and acquired as a traditional application system. It is a *set of information services* distributed across the NAS and coordinated through a hierarchy of responsibility. This hierarchy of data ownership will enhance operational decisionmaking by providing access to consistent, timely, high-quality NAS information.

How NAS Information Services Are Used

NAS information services will be managed and distributed across the NAS at three levels: NAS-wide, locally, and at the system level. Figure 19-4 distinguishes the basic set of information services by each of the three levels. The issue of data "ownership" is really one of distributed responsibility. The FAA will need to assign new roles (e.g., data administration and data base administration) at the three levels, and NAS users will be responsible for the aspects of information management that naturally fall within their area. For instance, air carriers initiate flight schedules and flight changes; the military manages special use airspace (SUA); and international aviation is active in oceanic airspace.

All three NAS user constituencies will structure their information services consistent with FAA information structures and services and vice versa. They will also have information management responsibilities due to their collaboration on numerous airspace situations, from severe weather (in real time) to ground delays (in near real time) to airspace design (archival/analytic) issues.

For domain-specific implementation information, refer to the domain sections (Section 21, En Route, and Section 23, Terminal). Details of information architecture not described in the domain sections will be developed as part of the information architecture process.

Information services will evolve as software and interfaces for new systems are developed or existing systems are upgraded or replaced. This will require a consistent set of standards and requirements that will apply to new software and operating systems, networks, and interfaces. The evolution is described generically in the following steps.

19.1.1 Information Services Architecture Evolution—Step 1 (Current–2000)

During Step 1, the NAS-level common information exchange implementation is primarily constrained within existing data management ser-

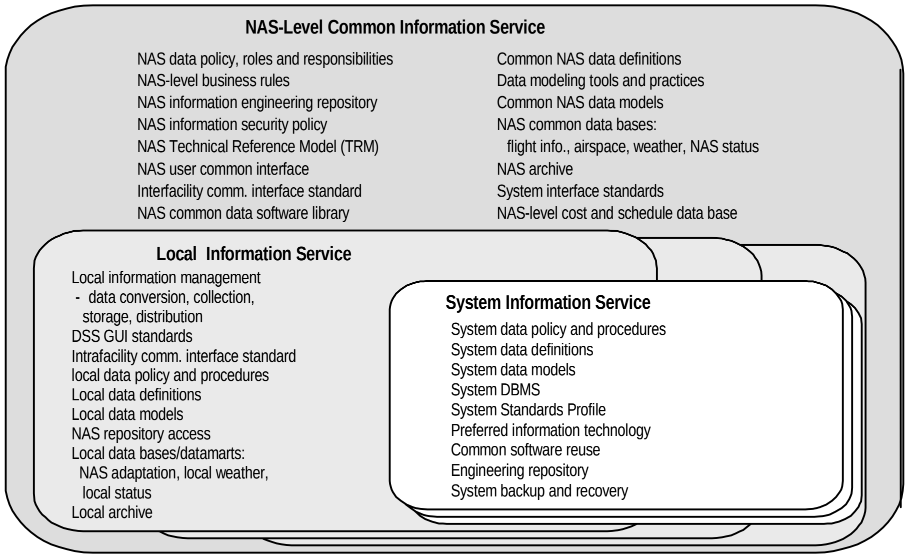

Figure 19-4. Three Levels of NAS Information Services

vices and legacy automation systems. Organizational and technical research groundwork will determine how to move from the way data are currently defined and managed within systems to a way that is compatible with coordinated systems, facilities, and NAS perspective. The initial tasks include:

- Maintaining and augmenting NAS user-to-system and system-to-system exchange of existing data
- Establishing new NAS-wide data management roles and responsibilities
- Baselining existing information definitions and requirements
- Developing data models to help guide the evolution of the information systems.

In transitioning from current information and transmission methods, data will continue to be available in its current form. Some data will remain in its current form in the future (e.g., data available over the Internet). Other data will be added to the current transmission media, particularly the Internet and data link.

19.1.2 Information Services Architecture Evolution—Step 2 (2001–2004)

A set of common, standardized information services supported by the local and NAS-level common information systems will begin to evolve during this step. Determining common data standards and structures will enable establishment of a central data repository for NAS-user access to some local data. Since security systems and procedures will not be fully implemented, external NAS users will access data from data bases established for that purpose, not directly from the applications that generate the data.

The flight object, as described in the CONOPS, significantly changes how flight data will be managed and shared in the future NAS (see Figure 19-5). First, as a replacement for today's flight plan, the flight object is much more comprehensive in scope and encompasses new data such as flight preferences. Second, the responsibility for processing flight object data will be distributed to different systems as a flight moves from preflight planning to in-flight operations to postflight analysis. Third, all data in the flight object associated with a flight will be made available NAS-wide and shared with NAS users as appropriate.

Key activities in the information services evolution during this time frame include:

- Developing requirements and standards for flight object data
- Developing standards for internal interfaces to the local information systems
- Developing standards for interfaces to external NAS users

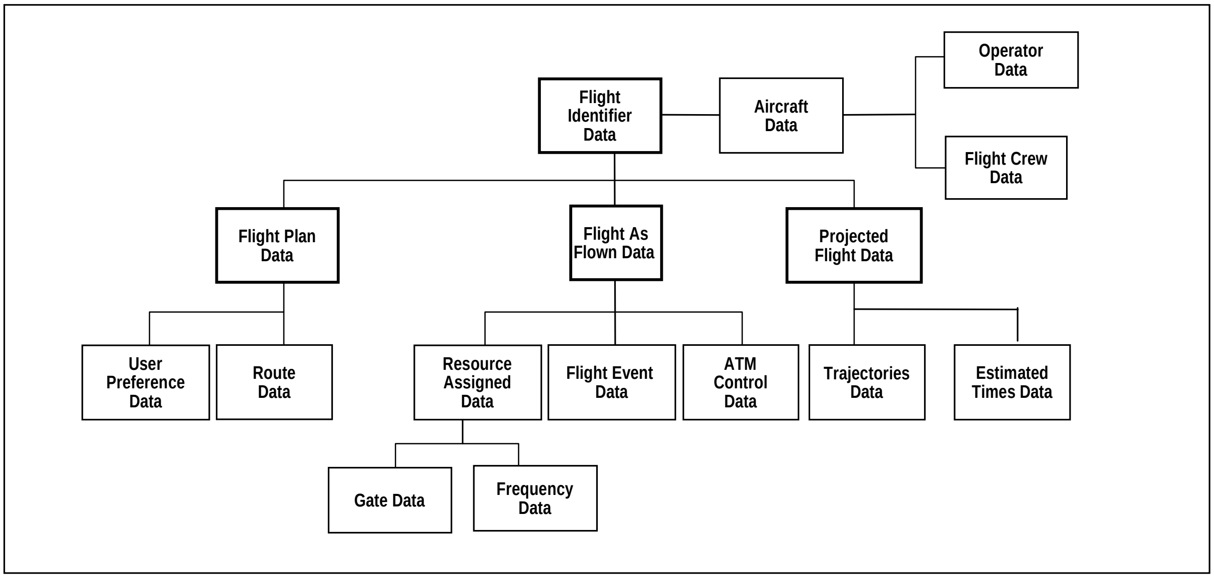

Figure 19-5. High-Level View of the Flight Object

- Implementing data security policies for local and NAS-level common information exchange
- Incorporating local information exchange capabilities into air route traffic control centers (ARTCCs)
- Providing NAS user data, including real-time SUA status and facility status
- Providing security for data access and exchange, as appropriate and available.

19.1.3 Information Services Architecture Evolution—Step 3 (2005–2008)

The set of common, standardized information services supported by the local and NAS-level common information exchange will continue to evolve during Step 3.

Key activities in the information services evolution during this time frame include:

- Developing requirements and standards for NAS resource (facility and airspace) status data
- Beginning deployment of local information system capabilities, tailored to support other facilities
- Providing security for data access and exchange, as appropriate and available.

19.1.4 Information Services Architecture Evolution—Step 4 (2009–2015)

A set of common, standardized information services supported by the local- and national-level information services will continue to evolve. All features—which are currently envisioned for NAS-level common information exchange that supports seamless data exchange within the NAS and with external users—will emerge in this time frame. Additional features will be developed as experience with the evolving NAS-level information services accumulates and as technology and user requirements evolve.

Key activities in the information services evolution during this time frame include:

- Completing and maintaining requirements and standards for all shared NAS data
- Beginning distribution of flight data to NAS users via the NAS-wide information network
- Making flight object data available NAS-wide
- Providing standardized, common data services support for NAS applications
- Providing NAS users access to all authorized NAS data
- Providing security for data access and exchange, as appropriate and available.

19.2 Summary of Capabilities

The modernized information systems will distribute timely, accurate, and consistent information in electronic format across the NAS, resulting in improved services to users, more efficient use of NAS resources, better flight planning, and more cost-effective systems development and acquisition. The information systems will provide users and service providers with a common view of the NAS for collaborative decisionmaking. Common, standards-based data services will provide data collection, validation, processing, storage, and distribution of data to and from data sources that are both internal (e.g., traffic flow management) and external (e.g., the National Weather Service (NWS), airlines, DOD, and international traffic flow managers) to the FAA. Figure 19-6, illustrates collaboration based on the Free Flight concept.

Data will be dynamically updated as situations change. Data types will include:

- *Flight Data:* Such as the filed flight profile and all amendments, first movement of the aircraft, wheels-off time, in-flight position data, touchdown time, gate or parking assignment, and engine shutdown. The current flight plan will be expanded to become the flight object and will include the added information about the flight. The information will be standardized to be consistent with ICAO standards. The user is one of the main sources of this type of data.
- *Resource Data:* Include static resource data, such as NAS boundaries, configurations, runways, and SUAs; and dynamic resource data, such as airport and airspace capacity constraints, current configuration of runways, system infrastructure status, schedule of SUA activity, and schedule of maintenance activity. The FAA is one of the main sources of this type of data.
- *Enhanced Weather Data:* Include current and forecast weather, hazardous weather alerts for windshear events (microbursts and gust fronts) and other hazards such as icing, turbulence, etc.
- *Traffic Management Data:* Include current and anticipated demand/capacity imbalances and planned strategies for managing them.
- *NAS Performance Measurement Data:* Provide information on NAS performance in a meaningful and readily accessible format for better planning.
- *Geographic Data:* Include terrain maps, obstruction locations, airspace boundaries, etc.

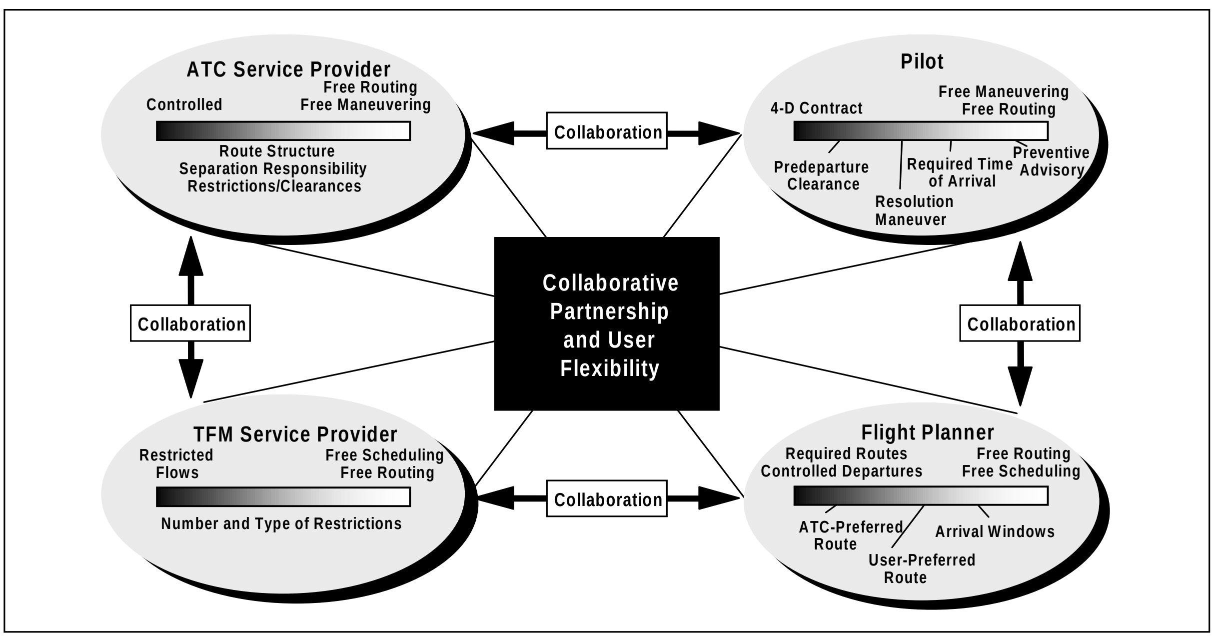

Figure 19-6. Collaborative Decisionmaking in the Future NAS and Electronic Data Exchange for Collaboration

- *Surveillance Data:* Include aircraft-position time and coordinates reports, velocity, and intent information.

The NAS is increasingly dependent on greater information exchange for better and shared planning and decisionmaking. The NAS-wide information network will provide NAS users and service providers with consistent, accurate, timely data to allow for future collaboration.

19.3 Human Factors

The new automation architecture and information-sharing processes will reduce human errors and improve throughput, workload, system confidence, and situational awareness. Human factors goals for this architecture are to:

- Reduce the potential for a human error (e.g., input error, or anomaly in one part of the system to adversely affect the performance of another part or person)
- Base the conceptualization, design, and development of the information interface with the user on the functions people perform and how and when they will be performed
- Define the information architecture in terms that include the user's task-related information requirements and the human component of relevant organizational modeling
- Determine the acceptance criteria for the data structure and standardization using factors that include human performance measures (e.g., for the end-product's utility and usability)
- Devise information architecture suitability and effectiveness measures that relate to operators' and maintainers' time- and event-derived tasks
- Optimize information architecture and implementation to clarify boundaries and procedures for controller and flight crew roles and responsibilities in collaborative operations and interactions
- Develop information architectures that promote the capability for air and ground displays to enhance common situational awareness among various users.

19.4 Information Security

All information service providers are responsible for information exchange security. This includes access privileges, data integrity and availability, and data sensitivity. Security will become a more complicated issue as the local and NAS-level common information systems evolve and as more information is shared among the FAA and NAS users. Protecting the integrity and privacy of FAA and NAS-user provided information will be critical to information exchange effectiveness. For example, users must have confidence in the data they access and confidence that sensitive or proprietary data they provide will be protected. New security systems and procedures will be implemented. See Section 9, Information Security, for a more detailed discussion.

19.5 Transition

The transition timeline for implementation of NAS information services is discussed next. The collaboration and information-sharing transition timeline is shown in Figure 19-7.

Information-sharing capabilities will be implemented during the following time frames:

- Near term: Local information services will include information directory/repository, decision support/data alerts, data management, security, system interface/information sharing, and data archive. Evolutionary steps will be:
  - Provide internal FAA facility information
  - Provide flight data to NAS users (including DOD) external to the FAA facility
  - Provide data access (search and query and publish and subscribe) capability to NAS users (including DOD) external to the FAA facility
  - Develop coordinated interfaces among legacy systems and for new and reengineered systems
  - Develop NAS information services, including data administration, data models, standards, protocols, and common data definitions
- Mid term: Expand information-sharing capability to address other specific information-sharing requirements

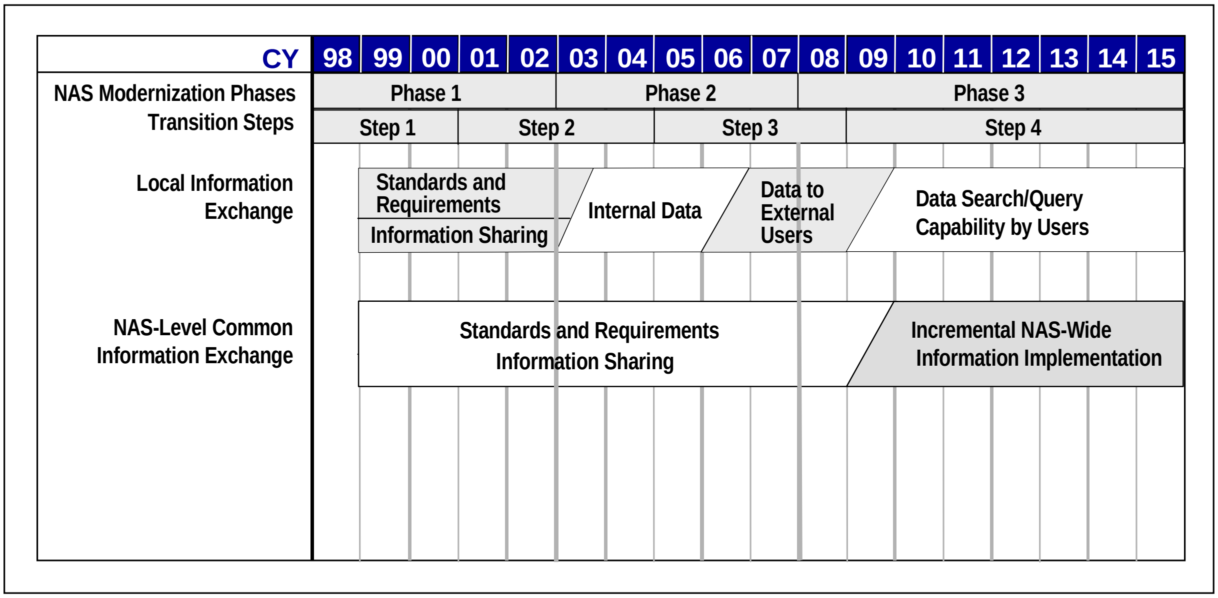

Figure 19-7. Collaboration and Information-Sharing Transition

- Provide demand data, such as flight information (flight object) and flight schedule information
- Provide capacity data, such as radar summaries, airport status, and airspace capacity/status
- Provide notices to airmen (NOTAMs) and weather data, such as hazardous weather warnings
- Implement NAS information services, which includes standards, protocols, and common data definitions

• Far term: Provide information sharing for the NAS operational concept

- Manage overall NAS information
- Plan and coordinate local and NAS-level common system infrastructure, which includes:
  —NAS data administration services
  —NAS information technology services
  —NAS data modeling services
- Maintain NAS information services, which includes responding to changes in standards, protocols, and common data definitions as requirements evolve.

19.6 Costs

Most of the FAA costs for NAS collaboration and information sharing are covered in the interoperablity costs for each NAS system. Other costs are shown in Figure 19-8. They include:

• Information modeling and standards development

• Standards management, validation, and conformance testing

• NAS-wide engineering knowledge repository development, implementation, and operations and maintenance

• Specific NAS-wide data bases such as a central adaptation data system.

19.7 Watch Items

• Identify priorities for delivery of collaboration information with users

• Establish policies for collaboration and information sharing. These policies are for:

- Authorizing access to specific classes and types of data for FAA and NAS users
- Allocating integration and interoperability responsibility among system developers, including clear guidance for commercially available versus developmental tradeoffs
- Accommodating ad hoc legacy systems for system interoperability and information

PART III

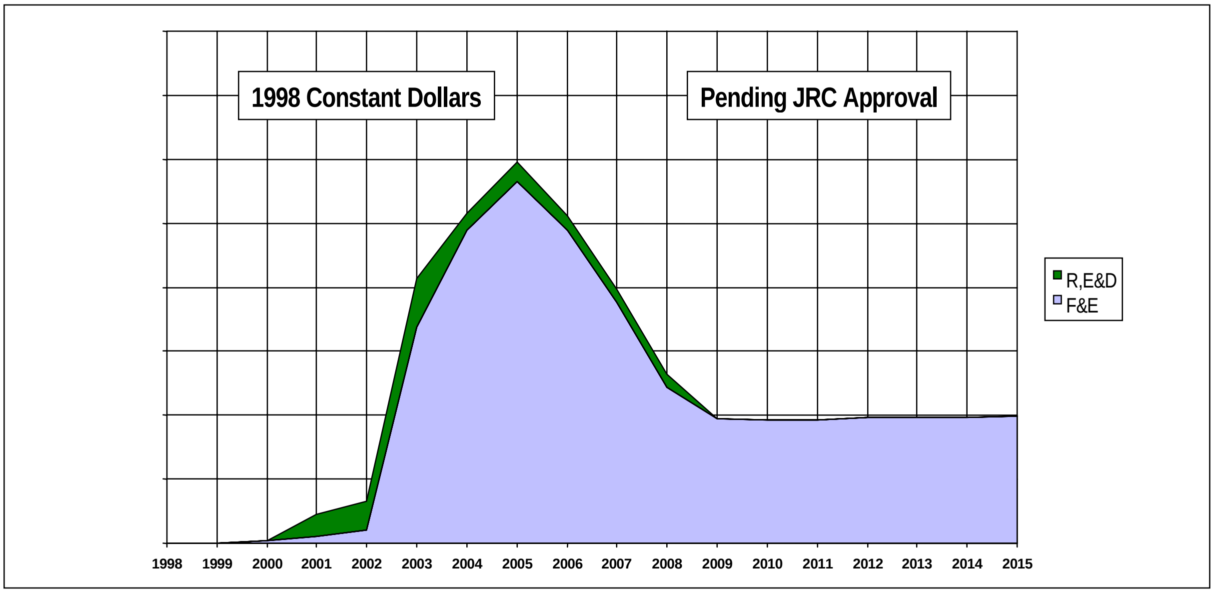

Figure 19-8. Estimated Collaboration and Information-Sharing Costs

exchange (e.g., operational data management system (ODMS), Systems Atlanta Information Display System (SAIDS), special use airspace management system (SAMS), etc.). These systems are currently used within the NAS to meet operational needs, but no requirements exist to access the data, or transition these needed capabilities into developmental systems.

20 TRAFFIC FLOW MANAGEMENT

Air traffic management (ATM) encompasses traffic flow management (TFM) and air traffic control (ATC) capabilities and is designed to minimize air traffic delays and congestion while maximizing overall NAS throughput, flexibility, and predictability.

This section addresses the functionality and evolution of the national and local TFM components of the ATM architecture. The description of TFM functionality includes capabilities at the Air Traffic Control System Command Center (ATCSCC) with some functionality distributed to traffic management units (TMUs) at air route traffic control centers (ARTCCs), at high-activity terminal radar approach control (TRACON) facilities, and at the highest-activity airport traffic control towers (ATCTs). To avoid duplication, only TFM functionality is described in this section. For descriptions of ATC functionality, see Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; and Section 24, Tower and Airport Surface.

TFM is the strategic planning and management of air traffic demand to ensure smooth and efficient traffic flow through FAA-controlled airspace. To support this mission, traffic management specialists (TMSs) at the ATCSCC and traffic management coordinators (TMCs) at local facilities (ARTCCs, TRACONs, and towers) use a combination of automation systems and procedures known collectively as the TFM decision support systems (DSSs). Modernizing the TFM DSSs includes new capabilities that will provide:

- More timely and precise data exchange between traffic managers and airline operations centers (AOCs)
- Enhanced analytical and display capabilities to facilitate FAA and industry collaboration in response to temporarily reduced NAS capacity
- More precise tools to analyze flow control data, performance, and decisionmaking.

These TFM DSS enhancements are expected to reduce industry operating costs by reducing flight delays, providing more predictability, and giving users operational control over their resources. Presently, sites with operational prototypes have experienced operational benefits.

The future TFM is based on the concept of operations (CONOPS), which has the goals of increased safety and improved traffic flow, and supports Free Flight concepts. This CONOPS relies on a substantial increase in data exchange and collaborative decisionmaking between NAS users (e.g., revenue carriers, business aircraft, general aviation, military, and international aviators) and FAA service providers (e.g., air traffic control and traffic flow management) and on development of improved NAS flow analysis and prediction tools.

The FAA will provide NAS users with data on the status of NAS resources and conditions, while NAS users will provide their daily operating schedules, intent, and preferences to the FAA. This data exchange is expected to improve the decisionmaking process for both FAA and NAS users. Collaboration will allow airline operators to have a much stronger voice in decisions that affect their fleet productivity rather than having those decisions imposed upon them. NAS users will be involved in collaborative decisionmaking in three ways: (1) providing real-time data to the NAS, (2) when appropriate, actively participating in flow strategy development and selection, and (3) modifying their operations to meet the collaboratively determined flow initiatives.

NAS flow analysis and prediction tools will support the collaborative development, selection, and implementation of changes in flow restrictions in the NAS. This will benefit both users and the FAA by ensuring that the NAS is operated efficiently.

20.1 TFM Architecture Evolution

Implementation of TFM services is limited by existing TFM technology, which includes hardware, operating systems, and various programming languages that have become obsolete and are unsupportable. To support current flow management capabilities and planned enhancements, the TFM infrastructure will be upgraded to an open client-server infrastructure.

The envisioned TFM capability upgrades fall into these functional areas:

- *Data Exchange:* Access to more timely and accurate information
- *Collaborative Decisionmaking:* Improved communications with users for operations negotiations
- *NAS Flow Analysis:* More automated tools to evaluate NAS status.

Specifically, these upgrades are based on the RTCA Free Flight Task Force 3 report (supplemented by Working Group 5 of RTCA Subcommittee 169), the FAA's interagency research and development plan, and the current CONOPS. The structured evolution of these capabilities is depicted in Figure 20-1. The infrastructure to support these new functions will be upgraded in a parallel effort.

The TFM architecture represents a phased approach to modernization. The approach will replace the current infrastructure (to include hardware, operating systems, program languages, and communication protocols using commercial off-the-shelf (COTS) data base management systems (DBMS) and a geographic information system (GIS)), improve current operating system functionality, improve the efficiency of existing functionality, and provide for the evolutionary implementation of new TFM capabilities. Central to the infrastructure evolution is a reengineering effort designed to provide an open-system, client-server infrastructure and modernized software architecture capable of supporting the increased functional capabilities.

The key objective of capability improvements will be incremental implementation of the high-benefit TFM capabilities as soon as possible. TFM software upgrades that are planned for the period between 1998 and 2015 are organized into four steps. Five upgrades to the TFM infrastructure are also planned for these steps. The following sections summarize the current system and the upgrades in each functional area for each step.

20.1.1 TFM Architecture Evolution—Step 1 (1998)

TMUs are located at the ATCSCC, all ARTCCs, and high-activity TRACONs. Some high-activity ATCTs have a subset of TFM functionality. Located near Washington, D.C., in Herndon, Va., the ATCSCC is a national facility dedicated to systemwide domestic and international planning and coordination. Once the sole location for traffic management activity in the NAS, the ATCSCC

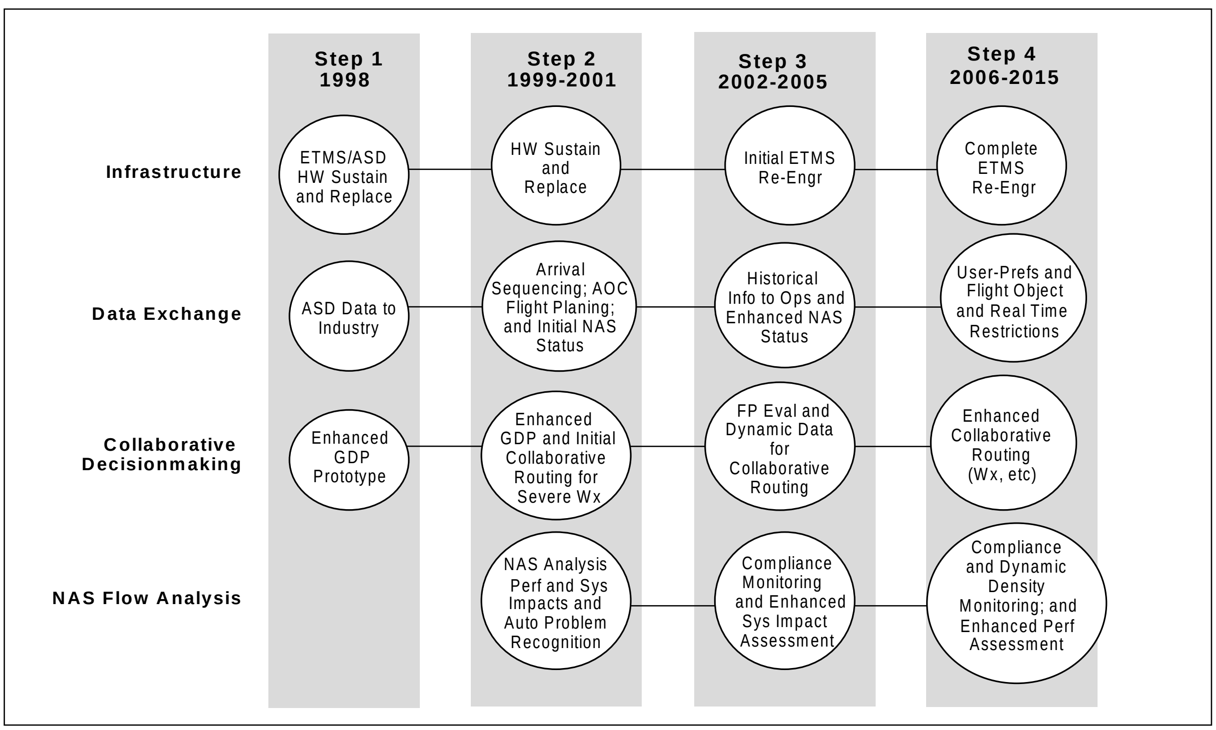

Figure 20-1. TFM Evolution

has evolved into a network of facilities with these key responsibilities:

- Monitoring air traffic and the status of airports and airspace across the NAS
- Coordinating with TMUs at local facilities to plan and implement restrictions as needed
- Assessing NAS performance and working toward long-term improvements
- Providing a central point of contact for NAS users and TMCs.

The TMSs at the ATCSCC monitor traffic, weather, resource capacity, and equipment status across the NAS to develop a systemwide perspective of NAS traffic flows and the implications of local situations (i.e., situations that affect the operations of a single en route center or a single approach control facility). TMSs are trained to work toward systemwide efficiency without allegiance to an individual en route center, approach control facility, or tower.

ARTCC and TRACON facility TMCs generally manage traffic situations affecting their airspace. They coordinate with neighboring facilities through the ATCSCC as needed and report status information to the ATCSCC. However, when traffic situations have broad impacts or when the underlying cause is extreme or long-lasting, the ATCSCC takes the lead in planning and coordination.

The ATCSCC develops flow management strategies that are implemented through the Ground Delay and Ground Stop programs, which are designed to respond to current capacity limitations due to adverse weather, runway closings, or other causes. The ATCSCC also oversees the National Route Program and monitors traffic at airports included in the Managed Arrival Reservoir program. Brief descriptions of these programs follow.

- **Ground Delay Program (GDP).** This program delays aircraft for a specific amount of time after their requested departure time in order to achieve a desired arrival rate at a destination airport. Appropriate departure delays are calculated to avoid excessive airborne holding. Controlled departure clearance times or estimated departure clearance times are assigned by a computer program at the ATCSCC, sent to host computers at the en route centers, and printed on flight strips. A prototype Ground Delay Program Enhancement system is being evaluated at the ATCSCC and selected AOCs.
- **Ground Stop Program.** This program stops all departures selected by the ATCSCC to a specific destination airport.
- **National Route Program (NRP).** This program allows flight planners to request use of specific routes in the NRP. Because the requested routes span en route center boundaries, the ATCSCC coordinates this program.
- **Managed Arrival Reservoir (MAR) Program.** For designated airports, this delay program eliminates the routine use of miles-in-trail restrictions on arrivals. The ATCSCC coordinates with local facilities to designate participating airports, and it monitors the actual use of airborne holding.

20.1.1.1 Current Infrastructure

Currently, the fundamental component of the TFM infrastructure is the Enhanced Traffic Management System (ETMS). ETMS provides a network of processors and workstations used by TMSs and TMCs to track and predict traffic flows, analyze effects of ground delays or weather delays, evaluate alternative routing strategies, and plan flow patterns.

ETMS data management and processing is centrally performed via the TFM hub. The hub is the processing engine that drives ETMS, and data provided by the TMUs are the basis for ETMS processing. The hub establishes and maintains a flight data base of active and proposed flights within the United States and adjacent oceanic air space. This data base is compiled from flight data submitted by the ARTCCs and some TRACONs and flight service stations (FSSs). Weather data, facility configuration, and facility status are maintained in separate hub data bases. ETMS has three major components:

- Applications at the ATCSCC that support national analyses
- Functions that centrally manage the ETMS wide area network (WAN) communications

by processing and distributing messages to all sites

- Aircraft situation display (ASD) functions that support AOCs, TMUs at local facilities (ARTCCs, TRACONs, towers, and regional facilities), and other users.

The current ETMS uses Apollo/Hewlett Packard processors for TMU display functions, hub routing and message processing, and ATCSCC functions. ETMS uses a point-to-point, proprietary communications system that features centralized processing with a star topology to connect the various TFM sites. ETMS applications were developed using Apollo processors and operating systems that are obsolete and no longer supported. The ETMS hardware and operating systems currently are being upgraded, and an effort is underway to translate the applications software to C language. This effort includes defining an application interface to use the transmission control protocol/Internet protocol (TCP/IP) socket-based interface and acquisition routers supporting the transition of communications to TCP/IP, which will be accomplished in Step 2.

20.1.1.2 Current Functionality

ETMS supports TMSs in assessing traffic demand by displaying, on a national scale, traffic location and volume and predicting air traffic flow hours in advance. ETMS is a tool for dynamically analyzing projected flow into sectors and airports, enabling preventive action to ensure that controlled areas are not overloaded.

ETMS provides these functions:

- **Traffic Display.** By monitoring the ASD, TMCs can evaluate traffic flow, demand, and available capacity at the national, regional, and local levels.
- **Congestion Prediction.** TMCs can anticipate periods of congestion with the monitor alert, which compares the expected number of aircraft at specific resources (e.g., airports and sectors) against established thresholds.
- **Arrival Analysis.** When arrival demand at an airport is predicted to substantially exceed capacity for an extended period of time, the TMSs at the ATCSCC can invoke a capability to develop a GDP.

ETMS extracts official scheduled data from the Official Airline Guide (OAG) and combines the data with data in the TFM hub. Data from these sources are used to produce the ASD. The GDP is used when air traffic demand is expected to exceed the arrival capacity at an airport for an extended time period. This situation is prevented by delaying takeoffs of some of the aircraft destined for that airport. GDPs use predictions of demand and capacity to produce a schedule of departure delays.

A version of ASD is available to industry and provides a national-level aircraft situation data feed to industry, enhancing the FAA's and industry's collaborative decisionmaking.

TMSs implement cross-NAS traffic restrictions, facilitate coordination among domestic and international service providers, and interact with AOC facilities and other NAS users. The ATCSCC mission is to balance air traffic demand with system capacity. It also uses the central altitude reservation function (CARF), the special use airspace (SUA) management system (SAMS), the dynamic ocean tracking system plus (DOTS Plus), and the high-altitude route system (HARS).

CARF manages military flight plans. SAMS provides historical data of SUA usage by both military and civilian air traffic. DOTS Plus calculates preferred oceanic tracks based on current wind conditions and records the assignment of flights to tracks. HARS provides routing for military aircraft over the contiguous United States.

20.1.2 TFM Architecture Evolution—Step 2 (1999–2001)

As part of Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD), AOCs and ATM personnel will use collaborative decisionmaking (CDM) capabilities to enhance flight planning. The FAA will provide participating AOCs with aggregate demand lists, anticipated airport acceptance rates, arrival rates, and parameters for anticipated ground delays. In the two-way exchange of information, AOCs will respond to the FAA with flight cancellations and revised schedules.

The FFP1 CCLD capabilities to be used for TFM include:

- *Enhanced ground delay program:* Uses two-way data exchange between the FAA and AOCs to facilitate better ground delay decisions
- *NAS status information:* Provides the NAS operational status to AOCs to promote a shared understanding of NAS traffic management decisions
- *Collaborative routing:* employs electronic chalkboards to share real-time traffic flow information with users to discuss potential routing alternatives around severe weather.

AOCs and the FAA will have the opportunity to access system performance, operational benefits, and acceptability. With positive results, these CDM capabilities will be fully developed, integrated, and deployed to suitable locations.

20.1.2.1 Infrastructure Enhancements

During this period, infrastructure enhancements will include TFM sustainment (hardware and operating systems), year-2000 compliance, and hub hardware replacement. This step replaces unsupportable software and hardware components. It is a stopgap effort to pave the way for future open system enhancements. Obsolete proprietary communications will be replaced with new software and hardware supporting TCP/IP. This is an essential step that forms the foundation for the migration of TFM infrastructure and functionality to an open systems environment. Installations of ETMS at new locations (TRACONs and ATCTs) will continue (refer to Sections 21, En Route; 22, Oceanic and Offshore; and 23, Terminal). The weather and radar processor (WARP) will become the primary source of ARTCC and ATCSCC weather data and will interface with TFM decision support systems (DSSs) that require weather support. ETMS will interface with the Standard Terminal Automation Replacement System (STARS) via a one-way interface.

20.1.2.2 Functional Enhancements

Data Exchange

Data exchange enhancements planned for this step include:

- *Enhanced Data Exchange for GDP:* Will provide data exchange to support collaborative decisionmaking between the FAA and AOCs to facilitate ground delay decisions by the FAA and efficient scheduling decisions by the airlines. NAS users provide actual cancellation and delay information to the FAA. The FAA will provide aggregate demand lists, anticipated airport acceptance rates, arrival rates, and parameters for anticipated ground delays. This updated current-day schedule information will become the basis for improved GDPs and more accurate monitor and alert predictions, which will reduce adverse schedule impacts on NAS users.
- *Arrival Sequence Display, Increment 1:* Will display arrival traffic schedules in TRACON TMUs as soon as a flight is airborne. This initial increment will be directed at TRACONs with a single dominant carrier.
- *NAS Status, Increment 1:* Will provide airport-related NAS status information, which is readily available from current systems and sensors, to other FAA facilities and to NAS users. Data for major airports are expected to include current and planned airport configurations, equipment status, arrival and departure rates, and weather data.
- *AOC Flight Planning, Increment 1:* Will provide the ability to exchange additional flight planning information with AOCs. This includes sharing constraint information (e.g., airport capacity), demand projections, and user schedule updates.
- *Post-Flight NAS Analysis, Increment 1:* Will provide historical information to service providers and users for post-operations analysis and long-range planning. This initial increment addresses information that is available in current systems or with minimal data entry.

Collaboration

Collaboration enhancements planned for this step include:

- *GDP Enhancements, Increment 1:* Will provide flight schedule monitor (FSM) that evaluates users' responses to plans for GDPs. The GDP improvements in Increment 1 to be incorporated into the FSM include:
  – *Ration by schedule* uses the OAG schedule and updates from users as the basis for the

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GDP. It ensures that airlines are not penalized for exchanging real-time schedule updates with the FAA.

– *Schedule compression* improves the current substitution process to allow more flights into slots available due to cancellation, thereby compressing the overall departure schedule.

- *GDP Enhancements, Increment 2:* Will include:

– *Flight substitution simplification* allows users to identify which flights are assigned to which arrival slots.

– *Control by time of arrival* gives users more control over scheduling their own aircraft and managing delays en route.

- *Collaborative Routing, Increment 1:* Will provide static data for use during periods of capacity restrictions typically caused by adverse weather. Several methods will be explored that allow participants to interactively determine general rerouting of aircraft around areas experiencing unexpected disruptions.

NAS Analysis and Predictions

NAS analysis and predictions enhancements for this period will include:

- *Performance Assessment, Increment 1:* Will establish and validate the metrics for measuring real-time NAS system performance from user and service provider perspectives. The performance assessment function records, stores, manages, and facilitates access to NAS performance data.
- *Automated Problem Recognition:* Will develop an early warning capability to recognize and measure projected resource demand and inform service providers and users when capacity is projected to be exceeded. More accurate projections of resource bottlenecks can be predicted because the airlines provide timely information about current flights.
- *System Impact Assessment, Increment 1:* Will help increase the understanding of system changes by developing fast-time simulation capability, thereby allowing more timely assessment of schedule changes, flight cancellations, and other operational modifications made by decisionmakers.

20.1.3 TFM Architecture Evolution—Step 3 (2002–2005)

20.1.3.1 Infrastructure Enhancements

Throughout the evolution of the TFM infrastructure, new installations of ETMS at various TMUs and remote facilities will continue. The initial ATCSCC local information services will be available during this time period. The TFM network will begin to be converted to be compatible with local information sharing and the NAS-wide information network (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

The reengineered TFM software will provide a modern, open-system architecture that will accommodate system maintainability, expandability, and increased processing requirements. It will replace custom code with a COTS data base management system and other COTS products. It will also integrate DOTS Plus, SAMS, CARF, and other new TFM capabilities, such as GDP enhancements.

By the end of Step 3, the flight data management (FDM) prototype will be implemented at the ATCSCC and interfaced to TMU workstations at selected ARTCCs for evaluation purposes. A modernized system is essential to the timely and cost-effective implementation of the TFM functional enhancements listed below.

20.1.3.2 Functional Enhancements

Data Exchange

Data exchange enhancements planned for this period include:

- *NAS Status, Increment 2:* Will provide static and some dynamic information on current and predicted restrictions and constraints, including active SUAs, agreements between facilities about crossing altitudes and speed, miles-in-trail, resource capacities, system outages, preferred routes, and weather conditions that could affect aviation.
- *Arrival Sequence Display, Increment 2:* Will provide real-time schedule updates of depar-

ture from the gate and airborne flight information, which will improve air carriers' planning. This increment will extend the initial capability to TRACONs with two dominant air carriers.

- *Post-Flight NAS Analysis Increment 2:* Will provide historical information to service providers and users for post-operations analysis and long-range planning.
- *AOC Flight Planning Increment 2:* Will provide the ability to use additional flight planning information within FAA automation systems.
- *Two-way ETMS-STARS interface:* Will enable the display of ETMS data on terminal and tower controller workstations.

Collaboration

Collaboration enhancements planned for this period include:

- *Collaborative Routing, Increment 2:* Will provide dynamic data for use by the FAA and NAS users.
- *Flight Plan Evaluation:* Will allow users to send a flight plan to the FAA to evaluate the route, altitude, and time of flight to determine whether the planned route will violate any NAS restrictions. The user receives feedback and can request the service provider to file the flight plan at both the ATCSCC and the appropriate ARTCC. This feedback is expected to include information about system constraints and options as well as operational rationale governing the acceptance, modification, or rejection of a flight plan at the time it is filed.
- *Collaborative Routing, Increment 3:* Will address severe weather avoidance areas with suggested reroutes during periods of capacity restrictions.

NAS Analysis and Predictions

NAS analysis and predictions enhancements for this period include:

- *Compliance Monitor, Increment 1:* Will evaluate and monitor NAS user compliance with collaboratively determined TFM solutions. This capability will allow TMSs to monitor and verify that users act in accordance with ATM restrictions. Industry participants are thus assured that they are not receiving any unfair operational penalty for participating.
- *System Impact Assessment, Increment 2:* Will develop fast-time simulation capability, allowing immediate assessment (within 5 minutes) of schedule changes, flight cancellations, and other operational modifications by service providers (based on expanded flight information). This provides decisionmakers with a better understanding of the impacts of specific actions.

20.1.4 TFM Architecture Evolution—Step 4 (2006–2015)

20.1.4.1 Infrastructure Enhancements

Infrastructure enhancements to the hardware and software will provide a COTS geographic information system, which will replace custom software. This will enable external queries in support of flight objects and provide the interface to FDM systems, local TFM functionality, and integrated arrival and departure schedules. Additionally, new ETMS installations at various TMUs and remote facilities will be completed.

The hardware and software will be fully compliant with the expanded information contained in the flight object. This will support distributed management of flight planning information, active flight information, and archived information, including post-flight analysis. The TFM infrastructure and applications will be fully integrated with the NAS-wide information network.

20.1.4.2 Functional Enhancements

The flight-object structure will be in place, and AOCs and other users will begin to use 4-dimensional (longitudinal, lateral, vertical, and time) trajectory information. The information captured will be closer to real-time than in the past. Tools will be updated to take advantage of the additional information in the flight object, such as gate preferences (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing, for additional information about the flight object).

Four-dimensional trajectories will be used in planning functions for the first time during this period. Negotiation of a proposed flight path will take into account NAS airspace status, and the flight object will be filed and updated as changes occur during the flight. This two-way data exchange will enable improvements to both the tactical and strategic DSSs to sequence aircraft to runways closest to the airline assigned gate and allow airlines to more effectively minimize their terminal turnaround time for aircraft.

Information available to service providers (e.g., TMSs and TMCs) will be greatly enhanced: NAS users and service providers can query the flight object and receive the status of any flight in the NAS. Simulation tools will allow NAS TMSs to anticipate and react more efficiently to dynamic changes in the NAS. Flight planning activity will be enhanced with more real-time data about the NAS and active and planned flights.

Traffic flow managers and controllers will have access to the same decision tools and flight objects. These tools, with adjustments to the look-ahead time, will become density tools for assessing the ripple affect of airspace changes. Modified trajectories can be developed collaboratively with AOCs, pilots, and other NAS users. The new trajectories can then be distributed to flight decks and downstream facilities. Traffic flow managers will have access to common ATM workstations as part of the TFM DSS.

Data Exchange

The data exchange enhancement for this period includes the Arrival Schedule Tool upgrade.

- *Arrival Sequence Display, Increment 3:* Will provide data/information to the airlines suitable for displaying arrival traffic schedules and real-time updates of flight plans and subsequently to the flight object when implemented.

Collaboration

The collaboration enhancement planned for this period is:

- *Collaborative Routing, Increment 4:* Will take into account other status information of the NAS, such as equipment availability, SUA availability, when suggesting reroutes due to severe weather avoidance.

NAS Analysis and Predictions

NAS Analysis and Predictions enhancements planned for this period include:

- *Performance Assessment, Increment 2:* Will expand the Increment 1 capability to establish and validate the metrics for measuring real-time NAS system performance from a user and service provider perspective. The system performance assessment records, stores, manages, and facilitates access to NAS performance data.

- *Compliance Monitor, Increment 2:* Will enhance the previous increment to accommodate new ATM collaboration information. It will evaluate and monitor service provider and NAS user compliance with collaboratively determined TFM solutions. This capability can be used by TMSs to monitor and verify that users act in accordance with ATM restrictions that may be imposed under the Free Flight concept. Industry participants are thus assured that they are not suffering any unfair operational penalty for participating.

- *Dynamic Density Monitor:* Will determine how best to measure density, including an enhanced monitor alert algorithm to measure the current (not predictive) state of traffic density.

20.2 Summary of Capabilities

The NAS-wide information network is designed to facilitate collaboration and information sharing between users and service providers. NAS users will be involved in collaborative decisionmaking by actively participating in flow strategy development, when appropriate, and by modifying their operations to meet air traffic flow initiatives. Collaboration and information exchange will reduce operational uncertainty, improve predictability, and enhance the decisionmaking process by allowing user input into decisions that affect daily operations. Daily system performance data will be recorded to enable quantitative measurements concerning the effectiveness and efficiency of NAS operations from both the FAA and user perspectives. These capacity-related metrics will include delays, predictability, flexibility, and accessibility.

The collaborative process establishes the data exchange capability that will be used to implement ration-by-schedule procedures. The procedures modify the GDP, using the airline schedule, as defined in the OAG as the baseline for allocating actual departures and predicting arrival times, rather than the individual flight estimate. The ATCSCC consolidates the schedule information and transmits it with information on airport arrival capacity constraints.

Control by time of arrival (CTA) provides users with more flexibility in operational planning. CTA uses arrival- rather that departure-based decisionmaking procedures, giving users more control over scheduling their own flights. Users will be assigned arrival times at destination airports and will be able to determine their departure and en route schedules to meet their designated arrival times.

Military scheduling agencies will provide real-time schedules for using SUA that allow sufficient time for service providers and users to incorporate it into their planning. As a SUA's status changes, the NAS is updated in real time, and commercial flights can be routed through it.[1]

Flight plan evaluation provides NAS users with immediate feedback about system constraints and options for their planned routes. This allows users to make timely revisions before submitting a flight plan. When a flight is airborne and operational factors dictate a reroute, the collaborative flight planning process will allow real-time changes, such as reroutes around severe weather or congested airspace. The airport configuration status will include active runway, equipment outages, weather, braking action, and visibility conditions. It will also include operational data, such as arrival and departure rates and types of approaches in use. The CDM process will also give users the opportunity to take part in deciding when equipment can be shut down for routine maintenance. See Figure 20-2 for a summary of the capabilities evolution.

20.3 Human Factors

Using complex automation systems to support human activity entails a common understanding of

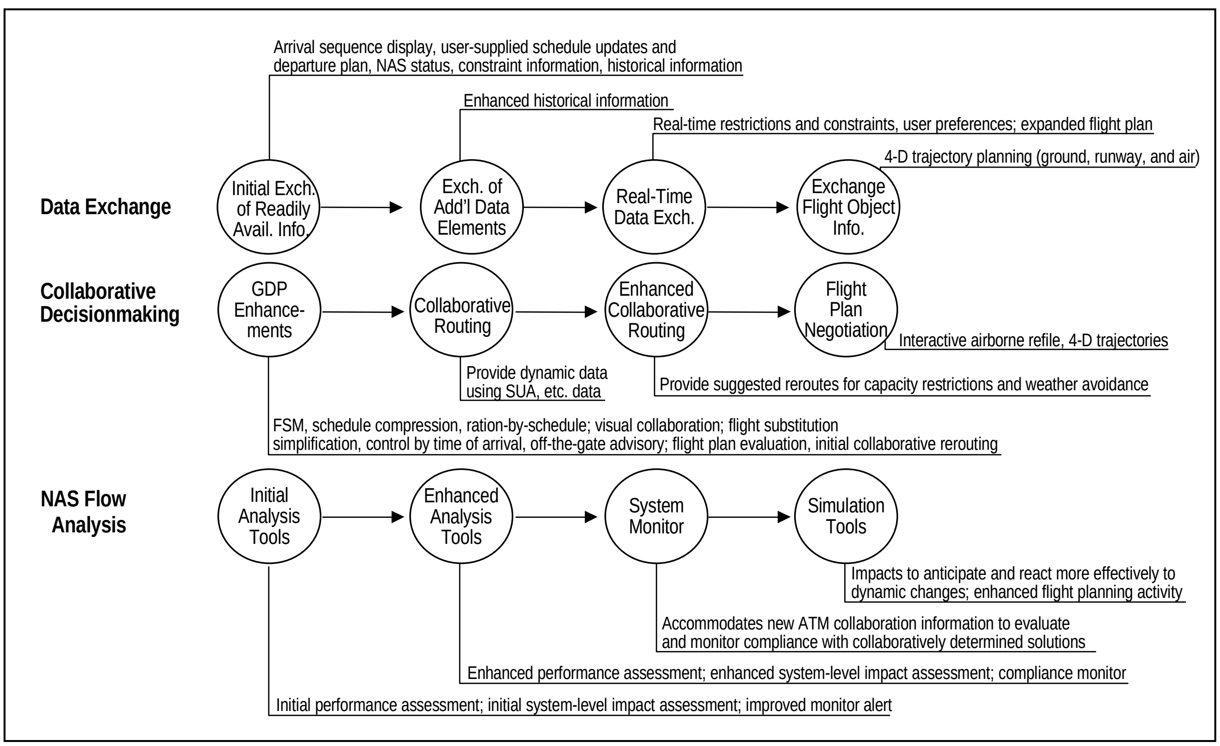

Figure 20-2. TFM Capabilities Summary

1. Generally, the SUA must be clear of commercial flights 30 minutes prior to being restricted to military operations.

intent of all the parties in the process. The collaborative decisionmaking process (already started with establishment of the airline operations center network (AOCNet) that provides information from the ASD to industry) will enable a closer coupling between AOCs and the FAA-projected traffic forecasts. This collaborative development approach ensures that both NAS users and service providers are an integral part of the design, development, and implementation of TFM capabilities. Improvements in throughput, workload, system confidence, and situational awareness will ensure that the capability will meet or exceed performance expectations.

The NAS architecture's increased level of effectiveness and efficiency of communications between service providers, facilities, and multiple users (including pilots and ground-based elements, such as AOCs) will improve the level of collaboration between parties in the system. This collaborative process involves more than just the transmittal of data across networks; it includes a coordinated understanding of the intents and motivations of the other parties. This communication, collaboration, and negotiation will be supported by various DSS tools to facilitate a rapid resolution to TFM situations. Communication methods and the information shared between parties will enhance the process of predicting the traffic flow constraints, evaluating candidate solutions, and executing the plans. The tools in place will be used by all the parties in the process and will provide for rapid and purposeful information exchange.

20.4 Transition

The transition for implementing the enhancements to the TFM Infrastructure in the three TFM functional areas is presented in Figure 20-3. The transition and the associated costs will be driven by increasing demand for the information and analytical tools necessary to implement TFM.

20.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for TFM from 1998 through 2015 are shown in constant FY98 dollars in Figure 20-4.

20.6 Watch Items

Appropriate information standards and information security must be implemented to protect sensitive and company proprietary data.

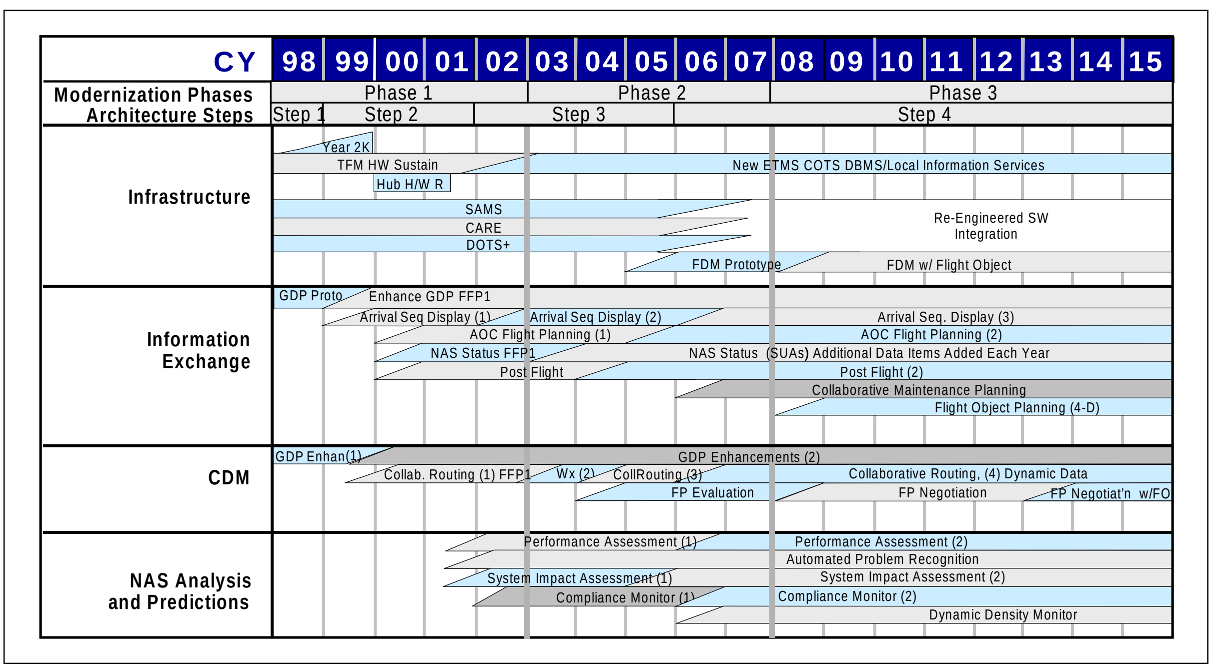

Figure 20-3. TFM Transition

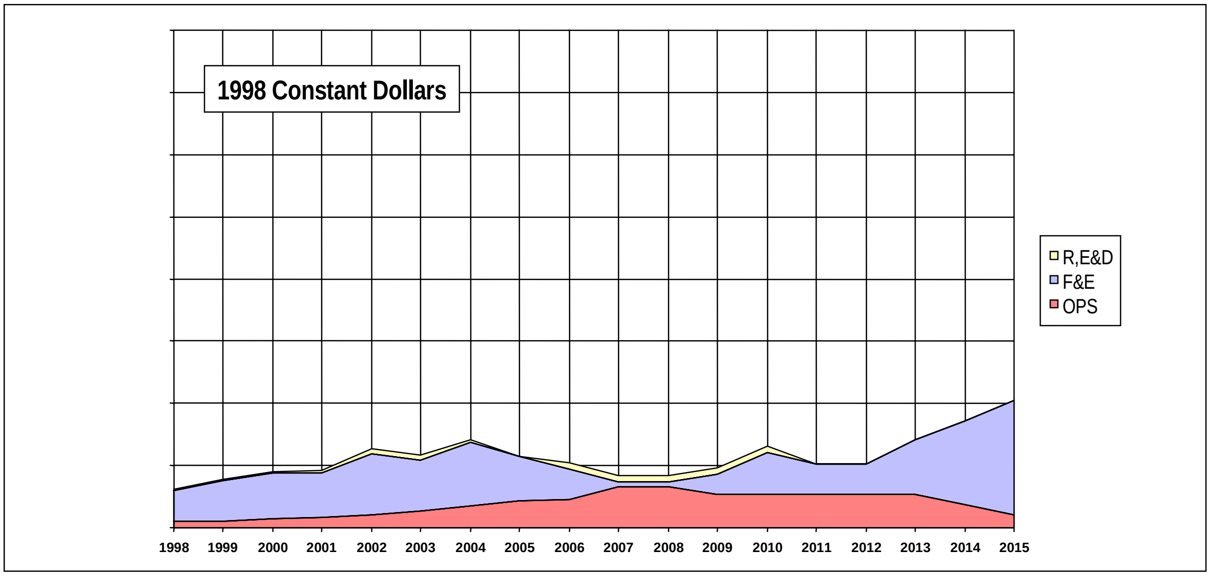

Figure 20-4. Estimated TFM Costs

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21 EN ROUTE

The En Route system is the core of information flow throughout the NAS. Air route traffic control centers (ARTCCs) are critical information hubs for the NAS. Replacing the en route infrastructure is critical to sustaining NAS services, assuring safety, and meeting user demand. The ability to sustain day-to-day NAS services takes precedence over implementing new capabilities. However, at the same time that the hardware infrastructure is being replaced to address immediate needs, it is also necessary to begin software redesign to resolve the fundamental limitations of the existing software architecture to enable the modernization needed to support user demands for additional services.

The *Government/Industry Operational Concept for the Evolution of Free Flight* defines the future operations and services for controlling aircraft in the en route domain. The operational concept focuses on an increased ability to accommodate user preferences using decision support tools for air traffic control (conflict detection, conflict resolution, sequencing to terminal, and optimal descent patterns) and traffic flow management (collaborative decisionmaking, NAS flow analysis, and data exchange).

In support of this, the en route architecture features revised flight data management (FDM), continuous access to expanded flight information (e.g., position, velocity, intended trajectory, preferences, etc.), improved decision support tools, and improved surveillance processing with more accurate position, velocity, intent, and wind information. New procedures will be developed to take advantage of the new operational capabilities. The operational concept emphasizes that the NAS will evolve to accommodate a flexible airspace structure, including dynamic airspace boundary restrictions and dynamic sectors. The en route architecture provides a basis for achieving the functionality defined in the operational concept.

The en route architecture is driven by the near-term need to sustain and then replace the en route automation hardware systems (e.g., host computer system (Host), peripheral adapter module replacement item (PAMRI), and enhanced direct access radar channel (DARC)). The en route architecture evolution provides user benefits as early as possible in support of the operational concept and the Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) plans. FFP1 is discussed in Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone.

21.1 En Route Architecture Evolution

The en route architecture seeks to sustain existing services while introducing new user services as early as practical. The first area of focus is the development of a stable hardware and systems software infrastructure with common operating systems and system services. New air traffic control (ATC) applications can then be put into place to enhance present en route capabilities.

Implementation of the en route architecture has been divided into four steps, beginning with the current operational prototypes and display upgrades and ending with enhancement and integration of the en route systems and decision support tools. An overview of the sequence and relationship of the en route functionality with respect to the en route architecture is shown in Figure 21-1. This figure and the figures for the en route architecture evolution steps show the initial operating capability (IOC) functionality. Before this deployment, extensive engineering development and integration is essential and must be funded to reduce the facilities and equipment (F&E) production procurement risks.

The first step includes replacing the Host hardware with Host/oceanic computer system replacement (HOCSR) to solve the end-of-service-life problems. It is important to note that currently, the software running on the HOSCR platform is essentially the same software architecture that was implemented in the early 1970s. The first step also includes completing the display system replacement (DSR) deployment, providing next-generation weather radar (NEXRAD) weather data to en route controllers, the prototyping efforts of center terminal radar approach control (TRACON) automation system/Traffic Management Advisor (CTAS/TMA), user request evaluation tool (URET), and the host interface device/NAS local area network (HID/NAS LAN).

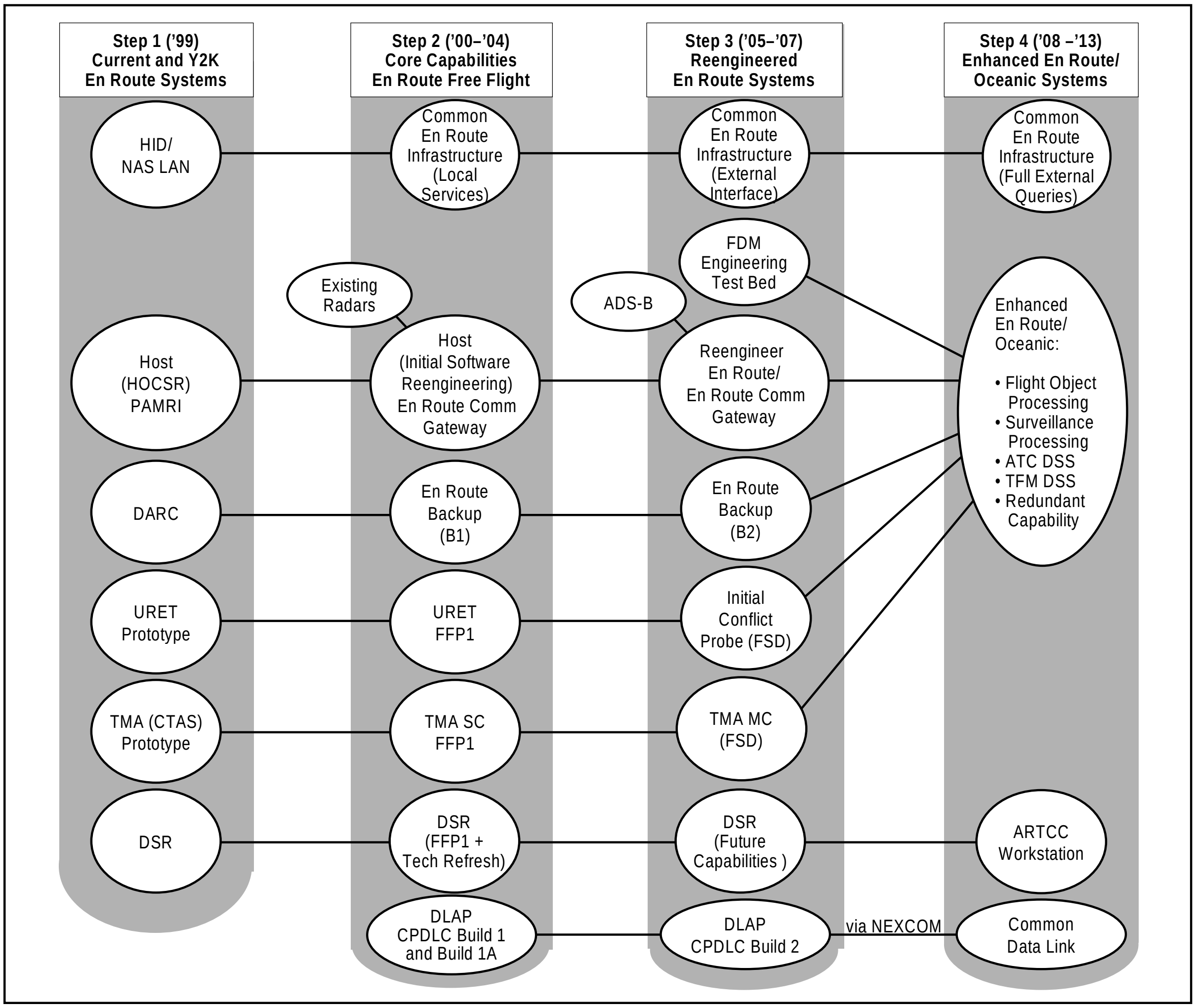

Figure 21-1. En Route Architecture Evolution

To introduce early functionality, en route capabilities will be expanded in the early stages with new applications executing on processors external to the Host/HOCSR—the first two of which will be the user request evaluation tool core capability limited deployment (URET CCLD) (evolved from the URET prototype) and TMA Single Center (SC) (evolved from the CTAS/TMA prototype).

In the second step, the en route FFP1 CCLD capabilities, (i.e., URET CCLD, TMA SC), along with controller-pilot data link communications (CPDLC) Builds 1 and 1A will be provided at selected ARTCCs. These functions are implemented on external processors and will be integrated into the core en route software architecture during the software reengineering in Steps 2 and 3. The integration will factor in lessons learned from the prototype implementations in FFP1 activities and the efforts necessary to make these products suitable for national deployment. URET CCLD implementation in FFP1 provides basic conflict probe capabilities to the en route center data-side (D-side) controllers[1] and will provide the capability for air traffic controllers to accurately predict aircraft trajectories 20 minutes ahead and identify potential conflicts. Initially, conflict probe will be implemented on a Host outboard processor at selected domestic ARTCCs and will subsequently be integrated into the coordinated ATC decision support system (DSS) tool set. TMA will acquire

1. D-side controllers assist radar-side (R-side) controllers.

flight and track data from HOCSR and calculate schedules for arriving aircraft and send them to specific TRACONs with meter lists routed to en route controller workstations.

Also in the second step, DARC and PAMRI must be replaced due to their anticipated end of service life. These replacements, along with HOCSR technology refresh, will provide platforms to be used until the enhanced en route architecture is in place. At this time, the Host software reengineering effort will also begin with surveillance processing modifications to take advantage of improved accuracy and additional information available from existing sensors and avionics. Additional modifications to integrate oceanic and en route requirements will eventually lead to common en route/oceanic processing. The reengineered Host, the replaced DARC, and the replaced PAMRI (En Route Communications Gateway) will enable radar inputs from additional terminal radar sources, which can provide additional surveillance coverage.

The evolution to the en route infrastructure begins with the DSR LAN and HID/NAS LAN and eventually results in a communications structure (i.e., the common en route infrastructure) through which all new en route functions will interface. Flight information will eventually be available to all service providers and NAS users using information services and the en route infrastructure. These information exchange services will be common with the oceanic, terminal, tower, and support facilities as described in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing.

Concurrent with the en route functional evolution is implementation of an improved infrastructure, which is a combination of data standards, interface protocols, and a complementary suite of utility support for accessing/storing information, operating system interfacing, and translating between new and old data/interface formats. The infrastructure and services form the connectivity basis for the addition of new en route functionality into the ARTCC and for external access to ARTCC data.

Initial data link service will be introduced at one key site. Initial operational CPDLC service for non-time-critical applications will subsequently be made available nationwide. Prior to nationwide implementation, users and service providers will have the opportunity to assess system performance, operational benefits and acceptability, and safety before further deployment. Introduction of data link services will involve modifications to software and will require the addition of an outboard data link applications processor (DLAP).

During the third step, en route systems will be upgraded to accept automatic dependent surveillance (ADS) reports in addition to all of the existing sensor inputs. The position of aircraft in nonradar areas will be available to air traffic service providers through processed ADS reports. This higher level of accuracy in aircraft position and the downlinking of additional aircraft state data, such as velocity and intent, will permit enhancing decision support tools to increase system capacity and user-preferred route availability.

Step 3 will deliver aeronautical telecommunication network (ATN)-compliant CPDLC services. At each stage, these data link capabilities will be merged with new and existing ATC automation capabilities to take full advantage of the improved timeliness, reliability, and efficiency that data link services will bring to the ATC system. Eventually, the en route and oceanic data link communications and application software will be integrated into a common system.

As an expansion of the FFP1 tools, the reengineered en route system in Step 3 will contain an integrated version of conflict probe (CP) and multicenter metering with descent advisor. Part of the engineering analysis in Step 3 will be the flight data management test bed designed to prove the concept of a universal format for flight objects within en route, oceanic, and terminal domains.

In the fourth step of the en route architecture evolution, the existing functionalities that are provided by multiple systems will be replaced by an integrated en route/oceanic system developed in the previous two steps. The new concept of flight data management uses flight objects identified in the operational concept and provides electronic flight information for display to controllers. The ARTCC ATC DSS tool set is the collection, enhancement, and integration of conflict alert, conformance monitoring, conflict probe, and conflict resolution tools, which will be implemented and then enhanced.

The ARTCC ATC DSS functions support aircraft separation from other aircraft, hazardous weather, terrain obstructions, and restricted airspace. The combination of improved surveillance intent information, the tools in ARTCC ATC DSS, and the flight object in FDM will permit accommodation of user-preferred trajectories. Additionally, the ability to dynamically modify sector and center boundaries will be included to help balance controller workload.

The following sections present the en route architecture evolution in more detail. Architecture diagrams (Figures 21-2 through 21-5) show the content of each step in a logical or functional representation without any intention of implying a physical design or solution.

21.1.1 En Route Architecture Evolution—Step 1 (Current–1999)

In Step 1, the DSR program replaces the display channel complex replacements (DCCRs), computer display channels (CDCs), and plan view displays (PVDs). The HID/NAS LAN is also introduced (see Figure 21-2). Implementation of HID/NAS LAN forms a basis for adding new functionality and outboard processing (such as CP, TMA, and data link processing), allowing early delivery of new capabilities.

The Host is currently part of the primary channel ATC equipment used in the 20 domestic centers. It provides radar data processing (RDP) for center controllers and flight data processing services for center, terminal, and tower controllers.

DARC is a backup system that displays radar data and limited flight data to controllers when the primary system is down. DARC supports two modes of operation: NAS/DARC mode and DARC-only mode. In NAS/DARC mode, the Host is fully operational and provides the DARC with an interface to flight data. In DARC-only mode, flight data previously received from the Host cannot be updated, so the currentness of flight data degrades rapidly.

The Host flight data processor (FDP) defines the airspace boundaries and processes flight plans for aircraft that pass through each area, ensuring that proper routings are applied. FDP also prepares paper flight strips for the appropriate sector, terminal, and tower as the basis for coordination among adjacent NAS facilities. Flight strips are used to record information provided to an aircraft and for coordination activities.

PAMRI is an interface peripheral to the Host, providing the conduit through which the Host receives and exchanges data, primarily radar data and interfacility flight plan data.

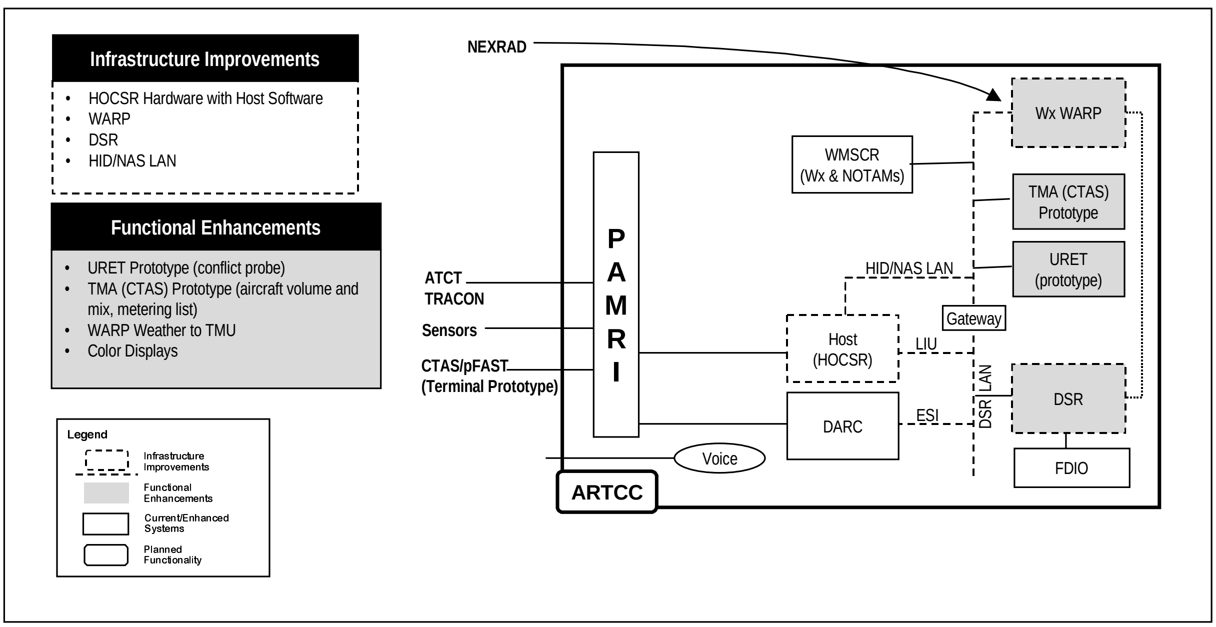

Figure 21-2. En Route Architecture Evolution—Step 1 (Current–1999)

The Host will be replaced in this step with a new platform, HOCSR, which uses the current application code with minimal modifications. Similar hardware replacement with HOCSR will be made for the oceanic display and planning system (ODAPS) (see Section 22, Oceanic and Offshore). This hardware replacement will solve the Host supportability problems.

At the Indianapolis ARTCC, a URET prototype is currently being evaluated for its ability to assist en route controllers in tactical planning to avoid potential downstream conflicts. A second URET prototype was installed in Memphis in 1997 to test conflict probes across center boundaries. Aided by forecast winds information, URET extracts real-time flight plan and tracking data from the Host, builds flight trajectories for all flights within or inbound to the center, and continuously checks for conflicts up to 20 minutes into the future. As the field trials progress, URET functionality is being displayed for use by the D-side controller. In subsequent steps, the URET CCLD FFP1 tool and full-scale development of CP will evolve from the URET prototype and the lessons learned in these field trials (see Steps 2 and 3).

The en route portion of the CTAS program includes a TMA tool for traffic managers and controllers in en route centers. This tool displays the volume and mix of aircraft destined for the entry points into the terminal area. CTAS/TMA provides miles-in-trail scheduling, time-based scheduling, and meter lists to controllers to ensure proper aircraft separation while increasing terminal capacity. This TMA function is a preproduction prototype installed at five high-capacity airports and associated ARTCCs.

HID/NAS LAN is a transitional infrastructure enhancement that will allow outboard processors for new applications to access the Host for data while minimizing use of the Host processor capacity to run the applications.

DSR provides color displays and will be delivered with new display interfaces to the Host/HOCSR. By the end of this period, DSR will display improved weather data from NEXRAD, which is processed by the weather and radar processor (WARP).

DARC, and PAMRI systems have reached the end of their service lives. Sustainment and replacement issues are discussed in the next step.

21.1.2 En Route Architecture Evolution—Step 2 (2000–2004)

In Step 2, PAMRI, and DARC functions will be sustained via replacement with modern platforms that can accommodate subsequent additions and modifications (see Figure 21-3).

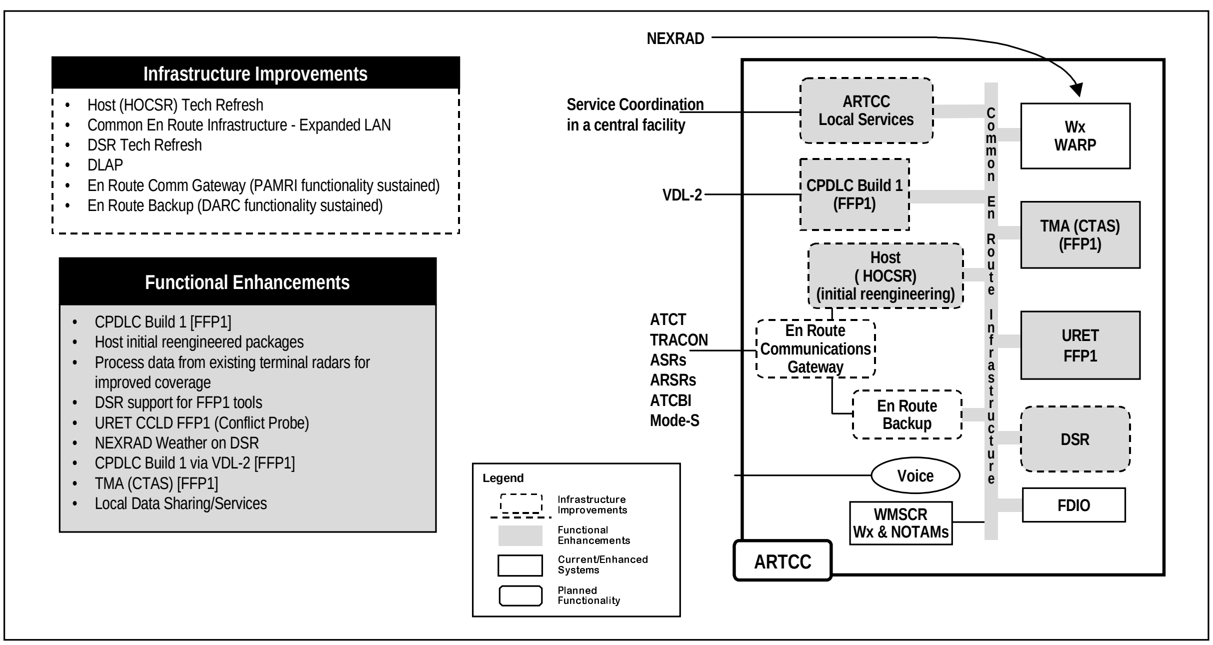

Figure 21-3. En Route Architecture Evolution—Step 2 (2000–2004)

Due to age and design characteristics, these current en route automation systems are limited in capacity and capability. They are also becoming unsupportable and limit operational flexibility within en route centers. The systems must be replaced with new systems that will support both current and future functionality and that can meet long-term availability, expandability, and efficiency requirements.

PAMRI will be replaced with the En Route Communications Gateway. It will be used in Steps 2 and 3 and will possibly be replaced for the enhanced en route/oceanic system described in Step 4. DARC will be replaced with a diverse (with respect to HOCSR) backup system, which will be used until Step 4, when a redundant capability will be incorporated in the enhanced en route/oceanic system.

URET CCLD is a limited deployment version of the functionality demonstrated in the URET prototypes and provides conflict probe core functions to selected sites identified for FFP1 CCLD capabilities. URET CCLD will use the DSR displays rather than outboard displays as in the prototype implementations. During Step 3, CP will undergo development and be deployed at all 20 domestic centers. Conflict probe functions will interface with HOCSR via HID/NAS LAN until its evolution to the common en route infrastructure.

The single center TMA tool will be implemented at selected sites for FFP1 CCLD, based on the TMA prototype described in Step 1. In future enhancements, TMA will include an improved descent advisory algorithm and time-based scheduling, and a multicenter TMA will be implemented in Step 3. Frequently, arrival streams to an airport have to be created, not only in a single en route center, but as a coordinated process with an adjacent en route center. By using aircraft track information across center boundaries, the trajectory can be modified earlier in the flight to minimize disruptions to traffic patterns while optimizing arrival rates.

Reengineering tasks will be performed to accommodate additional surveillance and communication sources and to initiate commonality with the oceanic domain. The HOCSR platform will provide the basis for developing common en route/oceanic processing. The surveillance processing in the En Route Communications Gateway and HOCSR will be reengineered to accept and process surveillance data from selected terminal radars. Additionally, these terminal sensors and many of the existing en route sensors can disseminate more accurate aircraft positional data to the automation system, as well as other valuable information that is presently not being utilized. This step will begin the process of redesigning the surveillance processing and other automation applications to make the best possible use of these sensor data. In this time frame, the complement of beacon sensors that will exist includes the monopulse ATC radar beacon system (ATCRBS) and Mode-S with ground-initiated downlink communications. It is anticipated that the addition of ADS coverage to this sensor mix will be accomplished in the next step. All terminal sensors will continue to have co-located primary radar surveillance.

The initial CPDLC Build 1 service for a limited message set, including transfer of communications (frequency change instruction), will be provided at one key site early in this step. CPDLC Build 1 is the first step toward achieving full CPDLC services. CPDLC will require software changes to the Host and DSR and the addition of an outboard DLAP. Users and service providers will have the opportunity to assess system performance, operational benefits and acceptability, and safety before further development. If results are positive, the CPDLC tool will be fully deployed nationwide. Subsequently, the initial set of non-time-critical CPDLC service will be expanded (Build 1A). These services will use more of the International Civil Aviation Organization (ICAO) CPDLC message set. Subsequent CPDLC builds will require further modifications to Host software, DSR, and DLAP.

The FAA's ground system infrastructure necessary to support these capabilities will include DLAPs located at each ARTCC to support en route and oceanic data link services and at each TRACON to support terminal and tower data link services. Each DLAP will contain the communication protocols and applications required. Initially, DLAPs will connect to communications service provider networks and later to FAA-provided networks.

The common en route infrastructure requires standards and specifications and protocols to be followed. The en route infrastructure will evolve in parallel with the infrastructure evolution of the other FAA domains (terminal, oceanic, tower, flight service) and the Air Traffic Control System Command Center. This first increment of local services and the associated infrastructure enable all intrafacility systems to share information with each other and, in future steps, to provide the means by which each facility shares data with other FAA facilities and NAS users. To achieve this, the services and infrastructure will include standards and a set of utilities for communication, data storage and retrieval, data monitoring, and recording. During Step 2, platform security will be implemented for en route computers, and the HID/NAS LAN gateways will be augmented to control access from remote systems.

21.1.3 En Route Architecture Evolution—Step 3 (2005–2007)

Reengineering surveillance processing and decision support algorithms initiated in the previous step will continue on a larger scale. Step 3 (see Figure 21-4) involves introducing new surveillance inputs, modifications to the en route communications gateway and related computer hardware, and systems software and related air traffic control decision support software algorithms.

To achieve the en route performance goals, all sensor data (e.g., data from primary radars, beacon interrogators, and dependent surveillance) will be used to the maximum. Using the Mode-S downlink capability for additional aircraft state data and the later adding of automatic dependent surveillance broadcast (ADS-B) data will both improve coverage and add to aircraft positional accuracy. These sensor data will include real-time information on aircraft velocity (airspeed, heading, windspeed, direction), acceleration (bank angle, climb rate), and intent (assigned altitude, intended waypoints). A key surveillance processing improvement will be the ability of sensors to disseminate and automation systems to accept surveillance reports in the common surveillance message format. The All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX) will provide the common surveillance message (described in Section 16, Surveillance).

Surveillance data processing (SDP) was developed to perform surveillance data fusion and reengineering of the decision support tools, which began in Step 2, and will be deployed to make maximum use of the additional data, accuracy,

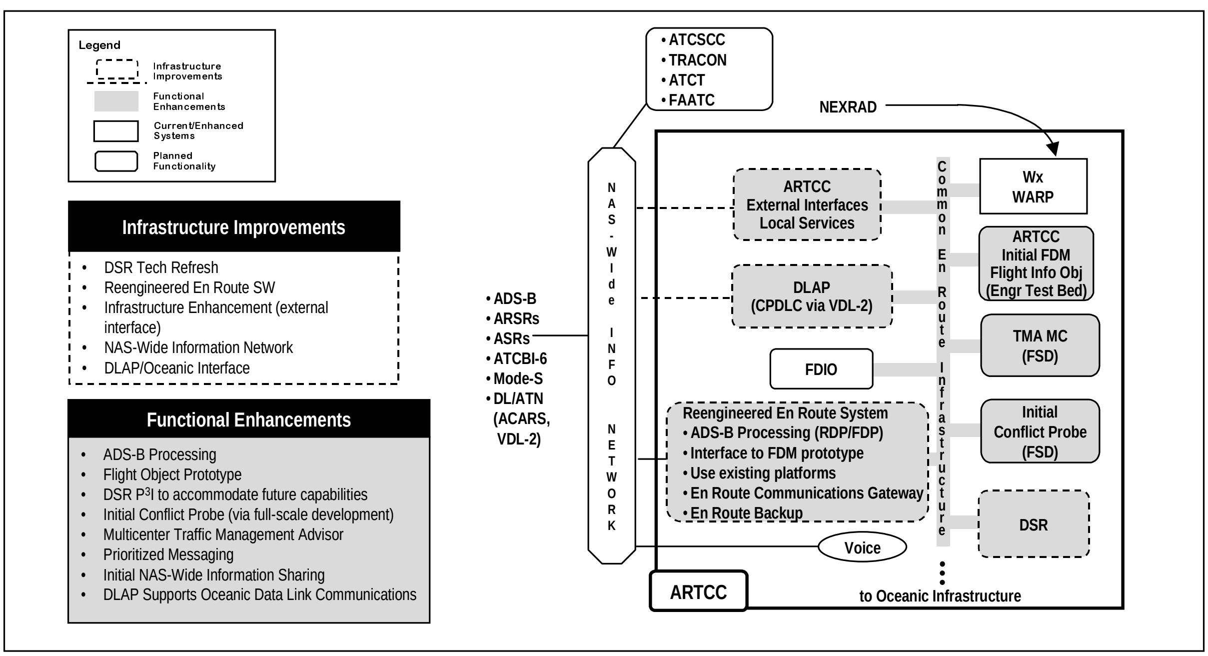

Figure 21-4. En Route Architecture Evolution–Reengineered En Route—Step 3 (2005–2007)

and update rates. These enhancements will permit increased traffic flow and allow more user preferred routes while enhancing safety.

Integrating the new data will require reengineering the en route communications gateway, the Host software, and related decision support algorithms. This is an evolutionary step leading to the en route architecture described in Step 4.

Developing and implementing a prototype FDM at selected sites is a risk-reduction strategy to verify use of flight objects and the display of additional data for ATC and user collaboration. This FDM prototype will be introduced into the en route, terminal, and oceanic domains, and it will be tested in shadow mode as an engineering test bed, in parallel with the operational FDP.

TMA SC will be expanded to include traffic management advisory capabilities across multiple en route centers (TMA Multicenter (MC)). This TMA expansion will also include improved descent advisory (DA) functionality by generating arrival clearance advisories as well as metering lists for TRACONs.

The URET CCLD FFP1 tool from Step 2 will be enhanced and deployed nationwide as CP. These enhancements will include improved computer-human interface (CHI), integration into the radar position (R-side), and other improvements.

Cutover to the next-generation air-ground communications system (NEXCOM) very high frequency digital link (VDL) Mode-3 voice operation is planned to take place in the high- and super high-altitude en route sectors.

The CPDLC message set will be expanded to approximately 100 messages (Build 2). DSR modifications will enable the en route system to display CPDLC information and new ADS-B data.

With development of the initial NAS-wide information network and common data services, applications will be able to send and receive en route information through local information exchange. This capability includes connectivity between FAA facilities as well as with NAS users through information sharing.

21.1.4 En Route Architecture Evolution—Step 4 (2008–2015)

In this step, the en route systems evolve toward a common hardware and software structure with the oceanic systems, although some applications may remain unique in each domain. The enhanced en route architecture (see Figure 21-5) implements FDM and advanced ARTCC ATC DSS tools. The need for a standard interface with NAS users drives implementation of the domain infrastructures and the local and NAS services.

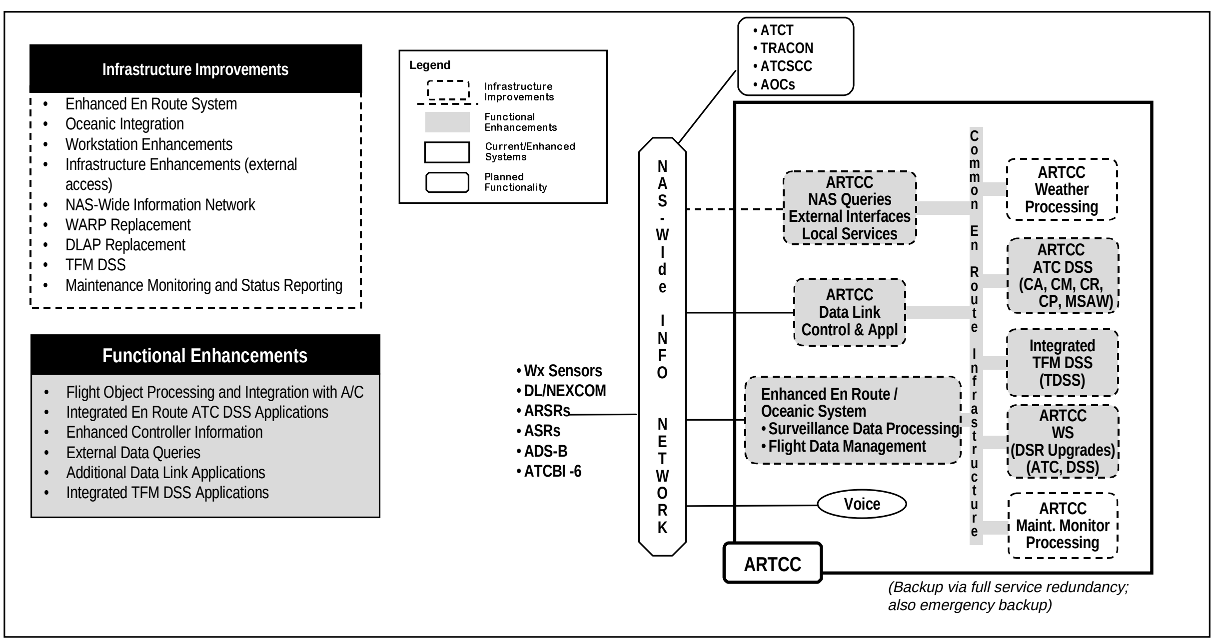

Figure 21-5. En Route Architecture Evolution–Enhanced En Route—Step 4 (2008–2015)

Surveillance processing will receive input from available sensors (e.g., primary radars, beacon interrogators, dependent surveillance), determine the position to be used for aircraft covered by multiple sensors, and provide the data (position, velocity, intent, etc.) for display and use by other DSS applications.

The replacement of FDP by FDM is driven by the operational concept approach of creating a flight object that increases the information within the flight plan and facilitates sharing of this information across domain boundaries with all authorized NAS users. In addition to expanding FDP functions in ARTCCs, the new FDM supports collaborative use at additional FAA and user facilities. The flight object contains all information about a flight (from the planning stage to the postflight archiving and analysis stages).

With FDM, flight plan processing and approval will be done nationally. Since the en route architecture is a logical architecture, the physical implementation of FDM is not implied. FDM will be implemented in a manner to prevent bottlenecks and loss of capability should one or more facilities be temporarily out of service. Each FAA air traffic facility will be capable of operating autonomously if necessary. Alternate facilities will assume FDM responsibilities in the event of an outage.

When a flight plan is activated, the flight object is retrieved and passed to the FAA ATC facilities responsible for that flight. As the flight progresses, the flight object data are automatically updated by the FDM at the controlling facility, and periodic updates are available through the NAS-wide information services for access by other FAA facilities or NAS users. FDM will archive the flight object during the flight and will maintain a permanent flight history. The content of the flight object is described further in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing.

The availability of improved aircraft position, velocity, intent, and wind information and the implementation of new automated decision support tools will assist controllers in separating aircraft from restricted airspace, hazardous weather, and other aircraft. It will also allow more user-preferred routes to be granted.

Full ATN-compliant CPDLC services (Build 3), including air-ground automation data exchange, will be delivered via NEXCOM. Introducing data link services will require modifications to the Host software, DSR, and DLAP. Data link via NEXCOM will provide time-critical data communications for ATC and will support collaborative planning such as user-preferred trajectories. CPDLC will support selective authentication of safety-critical messages.

Modifications to the content of and interfaces to controller displays will be required to accommodate the new integrated capabilities and flight object data. The following ARTCC ATC decision support tools will be integrated onto common platforms and the required reliability and accuracy will be maintained or improved:

- Conflict Alert
- Minimum Safe Altitude Warning
- Conflict Probe
- Weather processing interfaces to the air traffic control decision support system (ADSS)
- Conflict Resolution
- Descent Advisor
- Conformance Monitoring
- Multicenter Metering.

Additional tools will assist controllers in maintaining situational awareness and monitoring the status of airspace configuration (e.g., restricted airspace, hazardous weather location, sector boundaries). Data exchange capabilities will give service providers and NAS users an informed basis for collaboration on trajectory and strategic airspace solution planning.

Traffic flow managers and controllers will have access to the same decision tools and flight objects. These tools, with adjustments to the parameters (e.g., look-ahead time), will become density tools for assessing the ripple effect of airspace changes. Modified trajectories can be developed collaboratively with airline operation centers (AOCs), pilots, and other NAS users. The new trajectories can then be distributed to flight decks and downstream facilities. Traffic flow managers will have access to common ATM workstations as part of the TFM DSS.

Dynamic resectorization is an advanced concept that will allow ATC facilities to configure airspace boundaries in real time to accommodate varying traffic flows. ATC personnel will be able to coordinate minor sector boundary changes among themselves to reduce manual coordination and make their assigned airspace more efficient for existing traffic flow. These advanced concepts, which incorporate multiple center and sector reconfiguration capabilities, require further study to determine their feasibility.

In support of the en route enhancements, the infrastructure will provide these additional capabilities:

- Infrastructure and processing between en route and oceanic domains (New York, Oakland, and Anchorage) will be common.
- Local information service will accept and process queries from NAS users.
- Data link applications will enable common domestic and oceanic data link services.
- Automated monitoring and status reporting interfaces with NAS infrastructure management system.

The enhanced en route/oceanic architecture (see Figure 21-6) provides full ATC functionality for two physically separate, redundant systems. Each full-service system will perform all functions, interface with controller workstations, and receive data from all external systems.

An en route investment analysis will determine whether a tertiary backup system is needed to cover situations in which the primary and secondary systems both fail or are not available for some unpredictable reason. This analysis will also cover the safety implications of the various possible configurations and the impact of such issues as rapid cold start, warm start, recovery times, maintenance actions, and common-mode failures. Figure 21-6 shows a possible backup system with hardware and software diversity.

21.2 Summary of Capabilities

A stable hardware and systems software infrastructure with common operating systems and system services will be available at each step in the evolutionary system as a platform upon which ATC applications can be developed.

Initially, the en route FFP1 CCLD capabilities (URET CCLD and TMA SC), will be provided at selected ARTCCs. These functions are implemented on outboard processors, and will be subsequently integrated into the core en route software architecture during the reengineering of the host software. The integration will involve factoring in lessons learned from the prototype implementations in FFP1 activities and the efforts necessary to make these products suitable for national deployment. Figure 21-7 summarizes the capabilities evolution.

URET CCLD will allow controllers to accurately predict aircraft trajectories 20 minutes ahead and identify potential conflicts. URET CCLD will evolve to CP and be deployed nationwide. CP will be integrated into the en route automation, al-

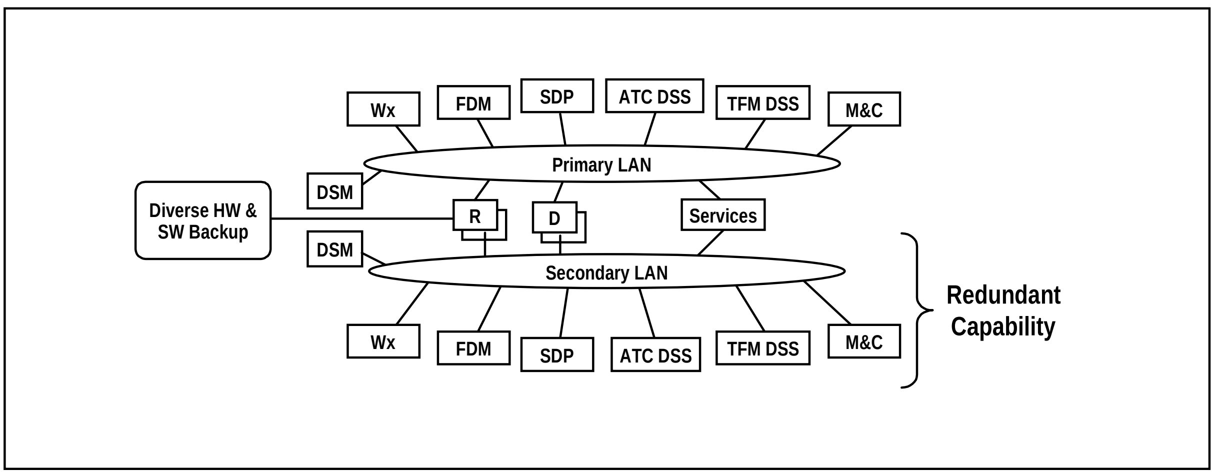

Figure 21-6. Redundant Functionality in En Route Architecture

lowing controllers to grant additional user-preferred routing.

TMA will assist controllers by calculating arrival schedules for sequencing to terminal facilities. The increased situational awareness will allow controllers to grant more user requests. TMA, which was initially deployed as a single center capability, will evolve to incorporate a multicenter capability allowing metering of aircraft to terminal areas across ARTCC boundaries.

CPDLC Build 1 will be initially installed at a single center so that controllers and pilots can gain operational experience with this capability. Subsequent national deployments will provide expanded operational information exchange by incorporating additional messages. Data link will provide additional interfaces for decision support tools as they evolve.

Implementing the flight object and the NAS-wide information services will allow data sharing across domains, facilities, and NAS users. This sharing will benefit users by enhancing the airlines planning to support daily operations. It will also improve the effectiveness of the ARTCC ATC decision support tools that provide both safety and efficiency benefits to all users.

En route automation will receive more accurate aircraft position, velocity, and intent information from both the Mode-S downlink and the ADS systems. ADS-B receives very accurate position determination from the Global Positioning System (GPS) and broadcasts aircraft information to other aircraft and ground facilities. This improved information used by enhanced DSS tools will improve en route system capacity and efficiency and may allow reduced separation standards to be implemented. Dynamic resectorization, to balance controller workload and potentially increase capacity, is a longer-term goal.

21.3 Human Factors

Implementing new hardware and software in DSSs, implementing new applications, and enabling en route technologies entails significant improvements in the way en route controllers conduct operations and provide traffic management services. Through an acquisition process that entails close collaboration with users, the resulting enhancements will provide new and different Air Traffic Service (AAT) and Airway Facilities Service (AAF) workforce tools, skills, procedures, and training. Some of the more significant increases to human-system performance include those related to:

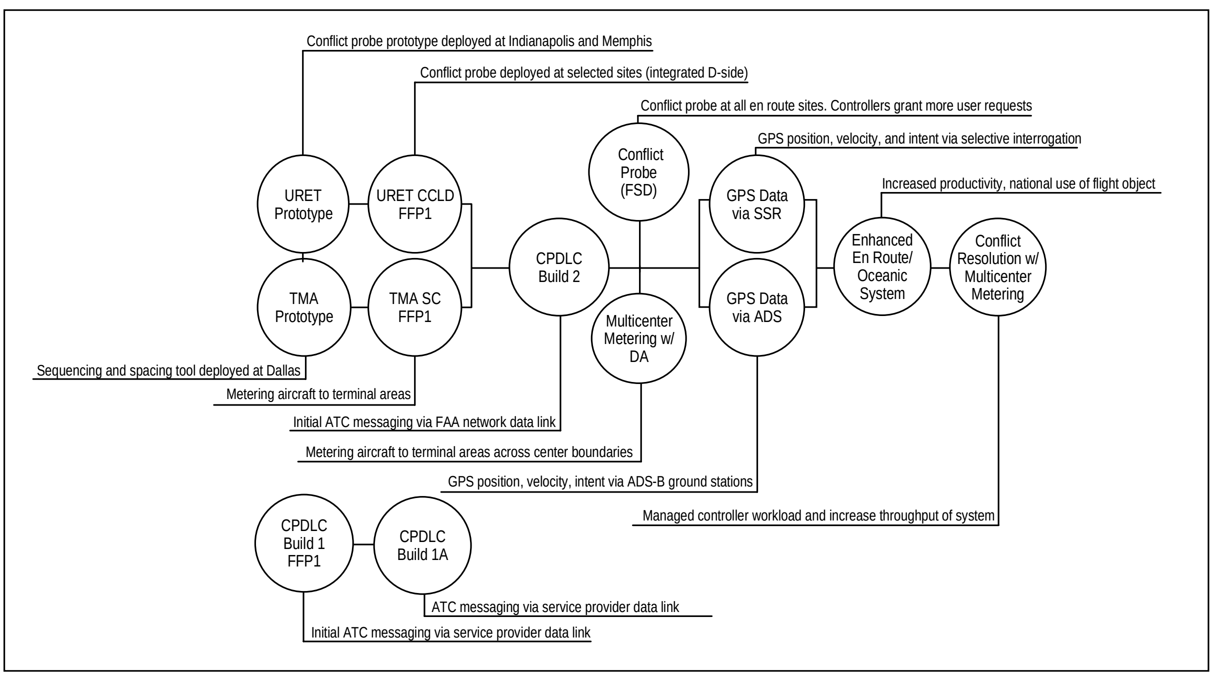

Figure 21-7. En Route Capabilities Summary

- **Information Dissemination:** Devising methods of distributing information among cooperative and collaborative en route decision-makers for such services as:
  - Advisories that inform ground and aircraft crews about alert/protected zone conditions, warnings, and resolutions
  - Common views and warnings of terrain, special use airspace (SUA), obstructions, and weather
  - Real-time reporting to users and service providers of radar, beacon, ADS, and other position information
  - Increased availability and updating of pilot intent and aircraft performance data
  - Information on integrity and timeliness needed to support flight object and DSS implementation.
- **Prototype Implementation:** Conducting the transition of prototypes for production and implementation such as:
  - Ensuring new functionality and/or CHI associated with individual prototypes or enhancements is effective and compatible (for operational/supportability) when integrated to form an evolutionary target en route baseline
  - Designing target workstations for the addition of new functionality (e.g., adequacy of the DSR data position (D-side) monitor for a conflict probe, availability of function keys on R-side, D-side, and monitoring and control (M&C) keyboards)
  - Clarifying the roles and responsibilities for new ATC applications (e.g., where DSR consoles are to be used for TMU positions).
- **Workstation Design:** Eliminating individual controller and maintenance workstation designs, divergent CHI, or incompatible CHI—especially where commercial software and application systems are prototyped and defined as independent systems that later interconnect to the Host via the HID/NAS LAN or are integrated into a single position or sector.
- **Failure Mode:** Designing (human) error-tolerant failure mode procedures, systems, and operations (under degraded or outage conditions) where there is heavy reliance on automated decision support tools for maintaining separation standards and tactical situational awareness.
- **Training and Transition:** Assessing training implications and transition requirements resulting from incremental implementation of new air traffic and airways facilities features and functionality and ATC functionalities that require significant use of common “display real estate” (e.g., tradeoffs between size of D-side glass and strip capacity).
- **Analyses:** Conducting en route analyses in support of:
  - DSR upgrades for enhanced color coding, operational display and input development (ODID) style graphical user interface, and revised CHI standard for R-side, D-side, and M&C positions
  - Baselining ARTCC en route operational and support work environments for additions to a configuration-management-controlled en route baseline
  - Design and development of a new and integrated ARTCC inventory of visual and aural alerts and alarms
  - Human factors investment analysis for the Host/DARC replacement and for en route conflict probe
  - Implementation of CHI design attribute allocation and configuration control systems.
- **Performance Measures:** Establishing objective en route measures for integrated human-system performance for such major milestones as successful completion of operational test and evaluation, initial operating capability, and operational readiness demonstration.

21.4 Transition

Figure 21-8 summarizes the en route activities transition.

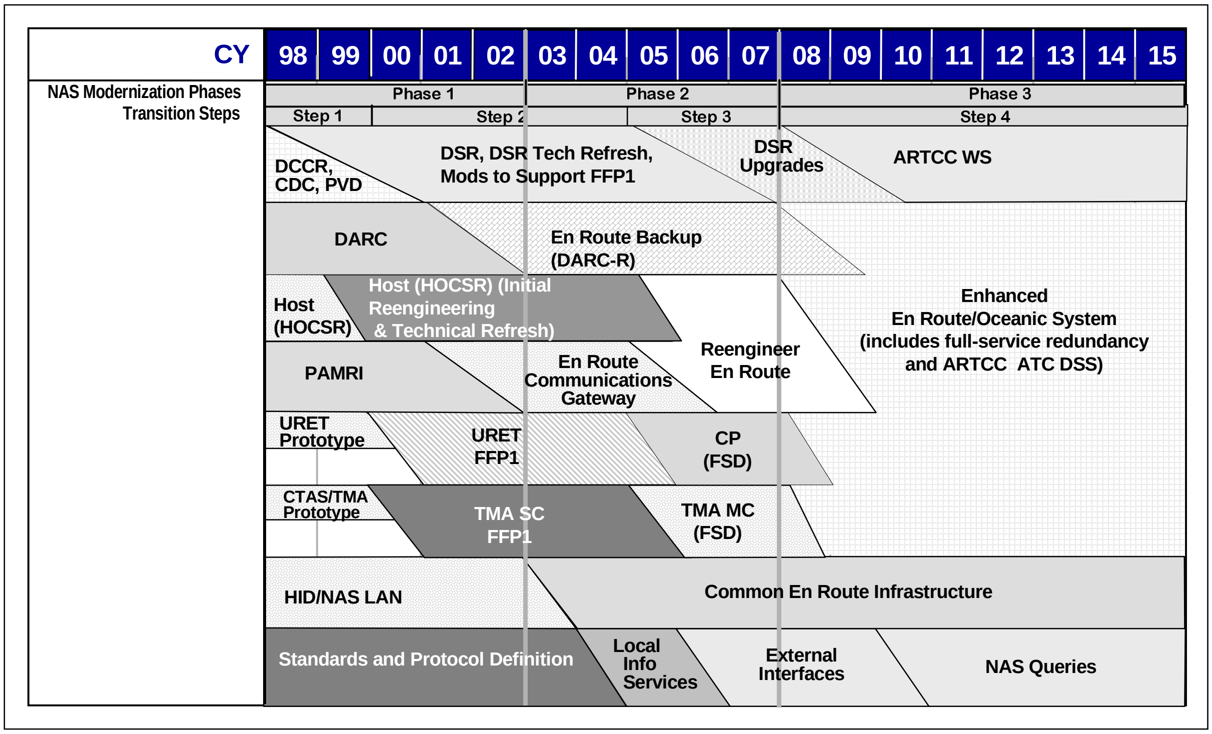

Figure 21-8. En Route Transition

21.5 Costs

The FAA's estimated costs for research, engineering, and development (R,E&D); F&E); and operations (OPS) are shown in constant FY98 dollars in Figure 21-9.

21.6 Watch Items

Achieving the en route functionality and operational benefits within the schedules and budgets described in the architecture depends upon the funding and success of the following related activities.

PART III

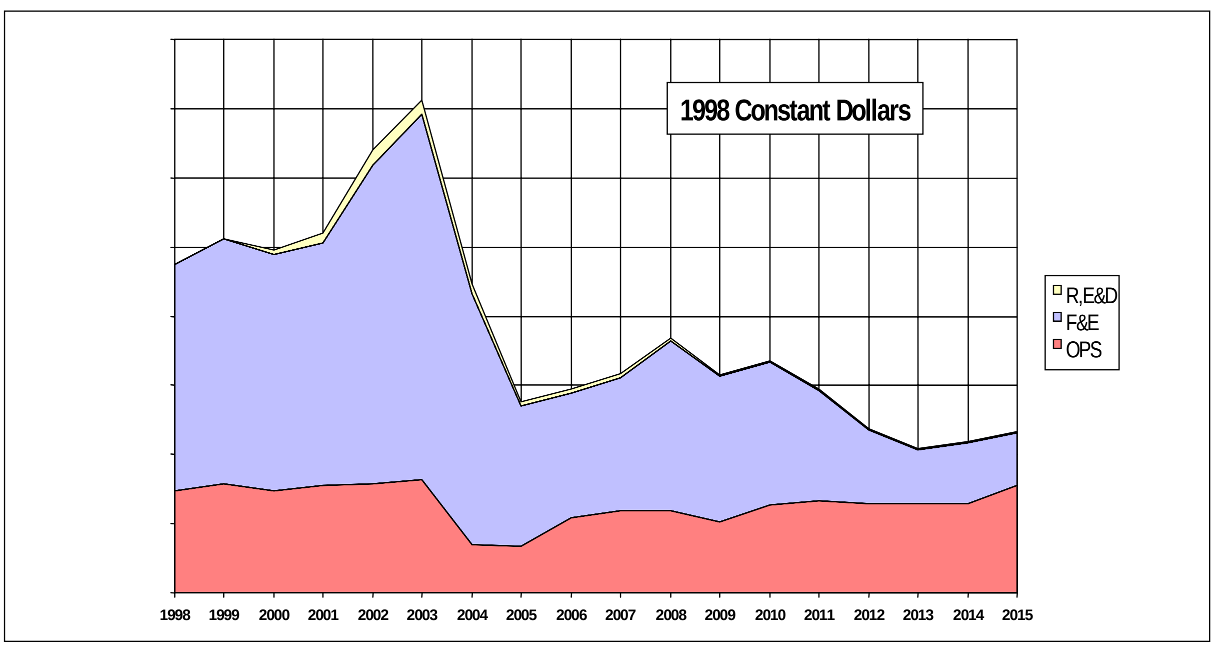

Figure 21-9. Estimated En Route Automation Costs

- Demonstrating the ability of ground automation systems to process improved surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS; to merge these data with radar data; and to display this information to controllers with an acceptable CHI. Results of these demonstrations would include processing algorithms and CHI standards that could then be incorporated into the en route core functionality between 2005 and 2008
- Timely deployment of the Host, DARC, and PAMRI hardware supportability solutions that solve the infrastructure replacement problems in the near term and provide a bridge to the new capabilities of the reengineered en route system
- Success of the FFP1 prototypes for the en route domain (URET and TMA SC) and conversion to production programs for initial conflict probe and TMA
- Transitional airspace structures and airspace redesign and their effect upon the labor-intensive effort necessary for site adaptation data maintenance. These affect both the current systems and the new decision support tools.

The budget for incorporating some of the future functionality is related to developing common algorithms to provide this functionality across domains where appropriate. Areas where common functionality across domains is anticipated are:

- Common surveillance processing and ADS data fusion in the terminal, en route, and surface domains
- Incorporation of more accurate surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS to improve decision support tools
- Common weather services
- Common flight object processing
- Common functionality in some ATC DSS and safety-related tools.

22 OCEANIC AND OFFSHORE

The FAA is responsible for providing air traffic services to aircraft flying within specific flight information regions (FIRs). These regions include a portion of the western half of the North Atlantic Ocean, a large portion of the Arctic Ocean, and a major portion of the Pacific Ocean (see Figure 22-1). The oceanic domain consists of oceanic air route traffic control centers (ARTCCs) and offshore sites. The New York and Oakland oceanic centers are responsible for oceanic airspace, while the Anchorage ARTCC provides en route (including radar coverage) and oceanic air traffic services for all Alaskan airspace. Air traffic services provided by San Juan, Guam, and Honolulu also fall under the oceanic offshore domain. Each of these latter facilities—commonly referred to as center radar approach control (CERAP) facilities or offshore sites—is unique in terms of their air traffic control (ATC) operations and associated ATC automation systems.

The future oceanic architecture must accommodate substantial air traffic growth that is expected in oceanic and offshore airspace through automation enhancements and procedural changes. These changes will reduce separation standards—longitudinally, laterally, and vertically. The *Strategic Plan for Oceanic Airspace Enhancements and Separation Reductions*, June 1998, describes the FAA's strategy to support the overall oceanic air traffic management (ATM) system improvement concept, including separation reduction and other airspace enhancements. A combination of ground and airborne automation capabilities and technologies in satellite-based communications, navigation, and surveillance will reduce or balance controller workloads to help oceanic service providers solve potential conflicts, traffic congestion, and demand for user-preferred trajectories. This architecture is centered around improving automation and communications capabilities in the ground system to take advantage of communications, navigation, and surveillance capabilities in aircraft avionics. A major goal of the architecture is to lower training, operations, and maintenance costs by evolving toward maximum commonality between offshore, oceanic, and domestic air traffic services.

Figure 22-2 shows that the oceanic ATC services of Oakland, Anchorage, and New York will evolve toward commonality with the en route domain, while Guam, Honolulu, and San Juan will evolve toward commonality with the terminal domain. The concept of commonality is that applications software will be common, where appropriate, but will also incorporate the domain-specific capabilities necessary for operational suitability.

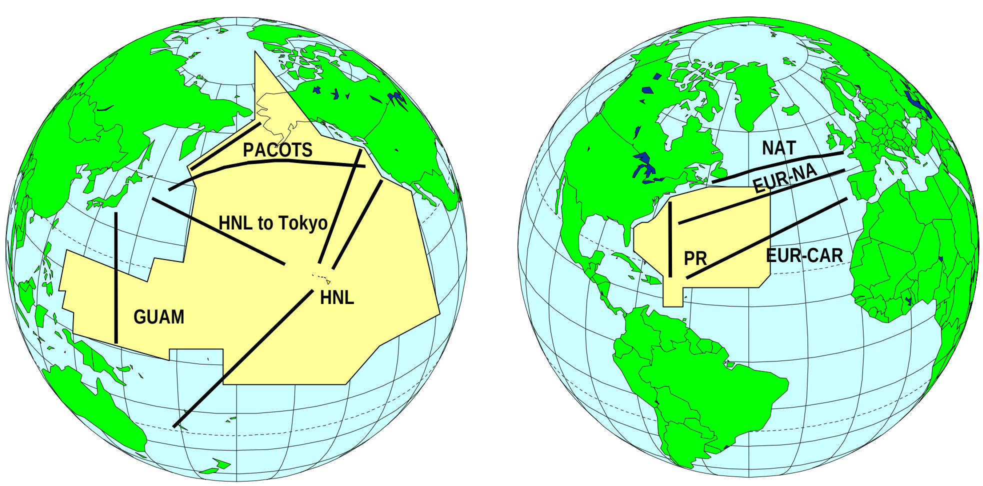

Figure 22-1. Oceanic Airspace

Oceanic airspace is an area in which airspace users can realize significant benefits from enhanced ATC system capabilities. Small improvements in fuel efficiency or reductions in flight times can create large savings in airline operating costs. Predictability of aircraft getting and staying on their preferred routing can be especially cost beneficial for the airlines.

22.1 Oceanic Architecture Evolution

Technical advances in automation and in satellite communications and navigation can increase user flexibility while increasing levels of capacity and safety in the oceanic and offshore domain. Automatic dependent surveillance (ADS), better navigation tools, near real-time communications, and automated data exchange between pilots and oceanic air traffic controllers via data link will provide the flexibility to change flight trajectories in response to changes in wind-optimal routes, rather than having to adhere to predefined routes that are calculated hours in advance. Oceanic service providers will have situation displays of traffic in oceanic airspace and decision support system (DSS) tools, allowing them to provide procedural separation from their displays at reduced separation minima.

Pilots will have a cockpit display of nearby traffic received via automatic dependent surveillance broadcast (ADS-B) from other aircraft. Pilots and service providers will be able to initiate and exchange data link messages via satellite communications (SATCOM) or high frequency data link (HFDL). Pilots will be able to negotiate climbs, descents, and specified maneuvers between affected aircraft and the oceanic service provider (see Section 16, Surveillance, and Section 17, Communications). Decision support tools will be used to help oceanic service providers detect and resolve possible conflicts and to prevent controlled aircraft from entering restricted airspace.

The role of oceanic service providers will evolve from performing procedural separation using paper strips to performing procedural separation employing situation displays and controller decision support system tools for separation and strategic planning.

The oceanic architecture will evolve through four steps leading toward commonality with the en route and terminal architectures. The evolution of the oceanic and offshore systems toward a common infrastructure will require close coordination with the acquisition efforts of other domains. These dependencies are discussed in the specific architectural steps. The applications software will become as common with other domains as appropriate. Domain unique requirements, primarily due to surveillance and communication differences, will be retained as necessary for operational suitability.

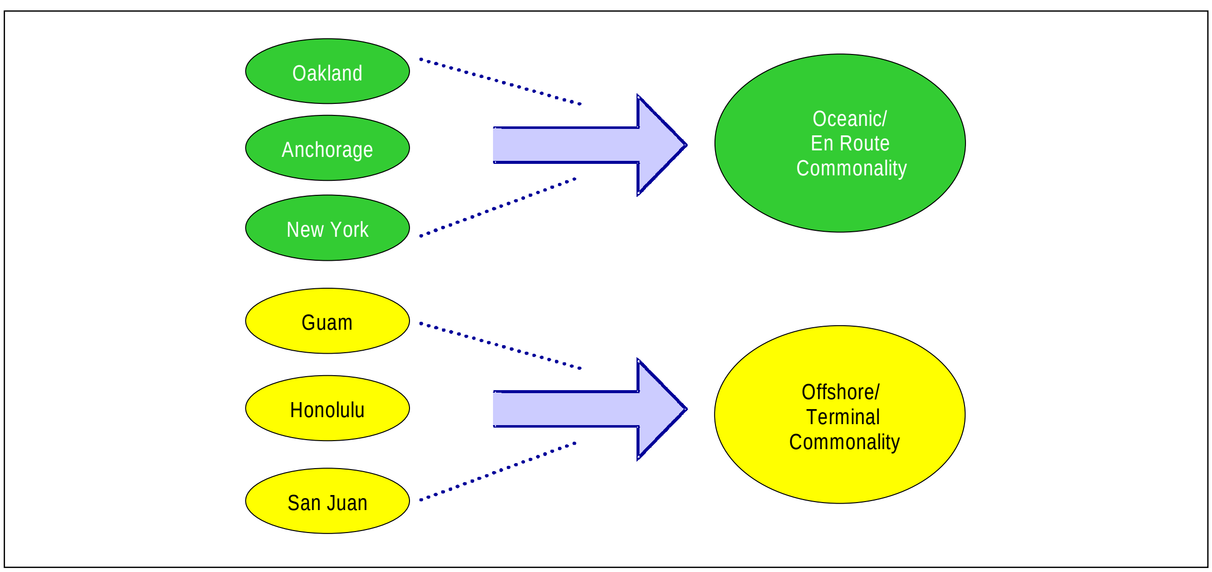

Figure 22-2. Oceanic Architecture Evolution Toward Commonality

The oceanic architecture is driven by the availability of enabling capabilities. The timing of specific capabilities is presented in Table 22-1. The table focuses on the evolutionary steps of the oceanic architecture. Table 22-2 presents the evolution of the concept of operations (CONOPS) in terms of the types of events experienced by users and oceanic ATC service providers for a typical oceanic flight in relation to the evolution of the NAS.

The oceanic architecture evolution is organized into two elements: oceanic and offshore sites. These sites include:

- New York and Oakland, which are oceanic FIRs, are discussed in Section 22.1.1, Oceanic Architecture Evolution.
- Anchorage, Guam, Honolulu, and San Juan are offshore sites and are discussed in Section 22.1.2, Offshore Architecture Evolution.

22.1.1 Oceanic Architecture Evolution

Currently, a number of innovative alternatives to meet oceanic user needs and commitments are being evaluated. This process could substantially affect the architectural evolution.

The architecture diagrams presented later in this section show the content of each evolutionary

Table 22-1. Oceanic Capabilities Evolution

	1998 Current	1999–2007 Steps 2 and 3	2008–2013 Step 4
Communications	HF voice through communications service provider Some FANS-1 data link	HF voice through communications service provider Direct communications FANS-1 data link (SATCOM) Some ATN Some HFDL	Rarely HF voice via communications service provider Some FANS-1 data link (SATCOM) Some HFDL Mostly ATN
Surveillance	Pilot position reports	Pilot position reports (voice or data) ADS-A ADS-B (air-air)	Some pilot position reports (voice or data) ADS–A ADS-B (air-air)
Navigation	RNP 10 Northern Pacific	RNP-10	RNP-4
Separation Standards	60-100 nmi long/lat 2,000 ft vertical 50 lateral nmi In-trail climb, descents RVSM Atlantic	50 nmi lateral leading to 50/50 nmi RVSM expanded to other areas Limited self-separation procedures	Additional self-separation procedures (Shared separation responsibility) RVSM
Airspace Structure	Fixed Flexible Random	Less fixed More flexible More Random	Random User-preferred profiles
Interfacility Comm	Voice Teletype NAS-to-NAS Initial AIDC	Voice Teletype NAS-to-NAS Data (e.g., AIDC)	Mostly data (e.g., AIDC) Some voice Some teletype NAS-wide information network
User/ATM interactions	User files flight plan User and TFM negotiate oceanic fix crossing time	Defines flexible tracks International collaboration for dynamic changes DARP reroutes	NAS-wide information network further facilitates new system applications
TFM	Defines flexible tracks Assigns fix crossing times	Defines flexible tracks International collaboration for dynamic changes DARP reroutes	Defines corridors
Airborne Equipment	Airborne collision avoidance system	Airborne collision avoidance system CDTI Cockpit multifunctional display (e.g., weather, etc.)	Airborne collision avoidance system CDTI Enhanced cockpit multifunctional display Additional applications

PART III

Table 22-2. Evolution of Events in Oceanic Domain

	1998 Current	1999–2007 Steps 2 and 3	2008–2013 Step 4
Users	For non-west coast flights with no gateway reservation, flights enter oceanic airspace at lower than preferred altitude or are delayed due to 10 or more minutes longitudinal separation required Uses HF voice communications via communications service provider (e.g., ARINC) Some FANS-1/A data link communications Reroute requests are time-consuming for pilot Pilot sees some traffic on TCAS display, most traffic out of range Pilots report waypoint position reports Few self-separation procedures (in-trail climb/descent)	For equipped aircraft, communication going from domestic to oceanic is seamless (both using data link) For some FIRs, seamless interfacility transition May request more reroutes (less workload intensive for pilot) CDTI displays more traffic, and ADS-B provides additional information ADS-A-equipped aircraft automatically sends waypoint and periodic position reports Limited self-separation procedures using ADS-B (air-air) and CDTI (in-trail stationkeeping, lead climb/descent)	Communications going from domestic to oceanic ATC seamless (mostly ATN) Seamless interfacility transition No need to request for reroute as long as maneuvers are within the corridor Pilot sees more traffic and weather information Able to fly preferred profile with shared separation responsibility
Service Providers	Altitude requests granted, if controller is not busy Ignores altitude profile information in flight plan; controller does not offer altitude change unless requested by aircraft or needed to resolve problem Reroute requests time-consuming for controller, limiting ability to grant requests Receives waypoint position reports from pilot Voice or teletype interface with other FIRs Prototype AIDC for limited data interface with other FIRs	Controller uses altitude profile information in flight plan for planning purposes Altitude requests more likely granted due to additional airspace available (e.g., RVSM), altitude profile information in flight plan, and controller less busy with manual tasks Reroute requests are more likely granted (less workload-intensive for controller) Receives ADS-A waypoint and periodic position reports from aircraft More data interface with other FIRs Automated decision support tools (including conflict probe) reduce reliance on paper strips	Few pilot position reports. Receives ADS-A position reports Flight Progress monitoring by exception Data communications interface with all other FIRs Flight Object processing facilitates handling change requests

step in a logical or functional representation, without any intention of implying a physical design or solution. An overview of the sequence and relationship of the oceanic functionality with respect to the oceanic architecture is shown in Figure 22-3.

22.1.1.1 Oceanic Architecture Evolution—Step 1 (Current–1999)

Current oceanic ATC systems at New York and Oakland do not rely on radar coverage. Operations are performed through procedural separation using paper flight strips. Air-ground communication is indirect through a third-party, high frequency (HF) radio operator. Since direct radar surveillance is not possible over most of the ocean, aircraft report their positions to oceanic ATC at prescribed intervals or locations as they progress along their flight paths. Navigation is performed principally with onboard inertial navigation systems (INS) and communication by HF voice. To allow for INS errors and communications uncertainties (e.g., atmospheric disturbances, indirect voice relayed through a third party and language problems), current oceanic separation minima are very large. Intensive coordination is required to ensure accurate communications between FIRs via teletype or telephone.

In the New York and Oakland centers, the Oceanic Display and Planning System (ODAPS) provides a situation display of aircraft positions based on extrapolation of periodic HF voice position reports and filed flight plans. ODAPS software was originally derived from the flight data processing software used by the en route Host computer system (HCS) and modified to meet oceanic-unique requirements. ODAPS also supports a procedural conflict probe capability. The ODAPS interim situation display (ISD) is currently used by service providers for planning and situational awareness. ISD does not yet provide the controller decision support tools required for it to be the primary means for procedural separation.

Oakland is currently using a limited version of oceanic data link (ODL) in a single sector. Oakland and New York sites have a telecommunica-

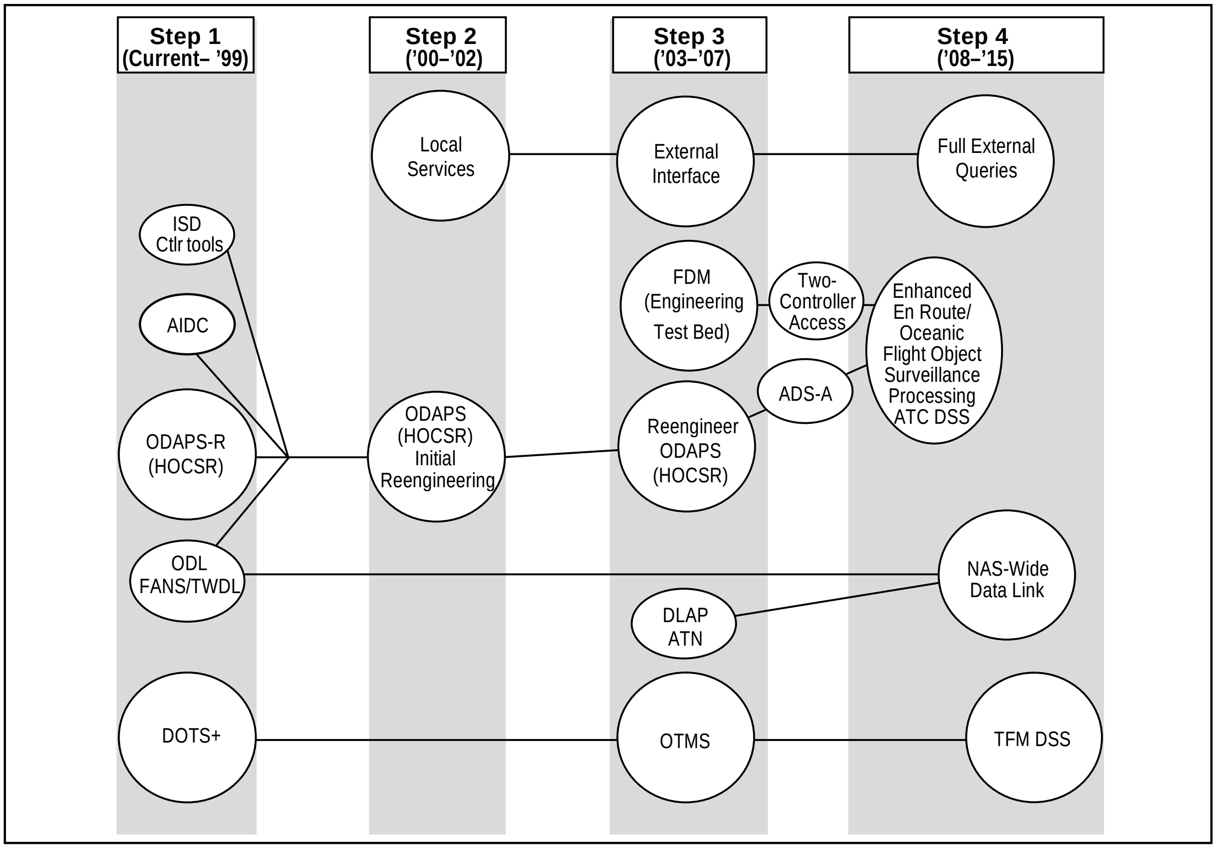

Figure 22-3. Overall Oceanic Architecture Evolution

tions processor (TP) that enables each sector controller to retain and search through ODAPS messages and messages received from the ARINC radio operators. The current oceanic workstations include an ISD and a TP/ODL prototype workstation that displays flight information. In addition, New York is using an air traffic services interfacility data communications (AIDC) prototype providing ground-ground data link between selected FIRs.

The oceanic centers also use the dynamic ocean track system (DOTS Plus) as a traffic management planning tool. DOTS Plus identifies optimal tracks based on favorable wind and temperature conditions, while projecting aircraft movement to identify airspace competition and availability.

An operational, procedural-based conflict probe will support reduced vertical separation minima (RVSM) and 50 nmi lateral through ODAPS. RVSM reduces vertical separation from 2,000 feet to 1,000 feet for aircraft in specified segments of oceanic airspace. Oakland implemented procedural changes to support 50 nmi lateral separation for properly equipped aircraft and for required navigation performance (RNP)-10 aircraft in the North Pacific Ocean. Procedural changes and international coordination will enable RVSM to be extended to the entire Pacific Ocean for equipped aircraft. This step also brings enhancements to DOTS Plus. Figure 22-4 illustrates the logical oceanic architecture during Step 1.

Enhancements to the oceanic architecture during Step 1 include:

- Procedural-based conflict probe checks oceanic flight plans and proposed revisions for potential conflicts and provide an alert if separation minima are predicted to be violated.
- DOTS Plus improvements include hardware replacement and functional enhancements, such as improved weather data, elimination of duplicate message feeds, track definition message interface to ISD, remote monitoring and software maintenance, and an enhanced graphic user interface (GUI). DOTS Plus expands upon the previous DOTS track genera-

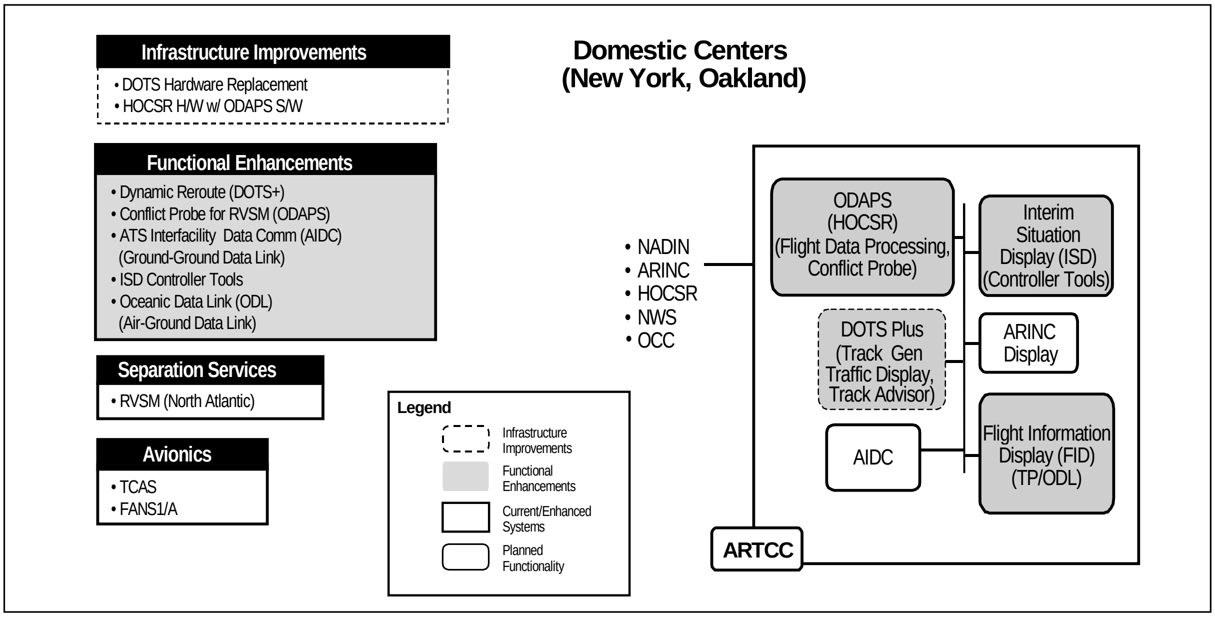

Figure 22-4. Oceanic Architecture Evolution—Step 1 (Current–1999)

tion, traffic display, and track advisor functions and is capable of supporting flexible tracks and dynamic reroutes. DOTS Plus enhancements streamline the process accounting for weather and balancing loads, and allow the tracks to be updated more rapidly.

- Multisector ODL supports air-ground data link communications and extend single-sector data link functionality to all ODAPS sector positions. In this early phase, ODL windows are displayed to the oceanic service provider on the flight information display (FID). However, if ODL is not running, the FID displays telecommunications processor data. This multi-sector ODL capability, via ARINC as a data communications service provider, uses satellite communications for exchanging messages with FANS-equipped aircraft. Data link functions include automated entry of flight identification into a list of flights entering the sector, a display of messages to the track control position, and a transfer-of-communication message to aircraft exiting the FIR.

- Initial AIDC supports the ground-ground data link communications, which enables message/coordination to be exchanged between U.S. oceanic FIRs and their equipped, adjacent FIRS.

- The ISD tool set introduces automated decision support tools to the controller for calculating time, speed, and distance for head-on, in-trail, and crossing situations.

- The ODAPS hardware will be replaced to solve end-of-life-cycle and year 2000 problems. The en route program, Host/oceanic computer system replacement (HOCSR), will replace the en route and oceanic hardware. The current oceanic functionality will be sustained using the existing ODAPS software on the same hardware platform that is being used for the en route automation system. The economies of scale enabled by using common hardware for oceanic and en route applications will result in lower life-cycle costs. Moving to a common hardware platform will also provide a starting point for the evolution to a common software architecture to support oceanic and domestic ATC applications, as discussed in Section 21, En Route.

RVSM (North Atlantic) enables properly equipped aircraft to be cleared closer to their optimum altitudes and to be closer to the wind-optimal routes. Conflict probe helps enable conflict-free clearances and provides additional flexibility in granting user-requested routings in a timely manner. DOTS Plus provides flexible tracks, enabling the system to be more responsive to changing wind conditions.

Improved air-ground communications and coordination (enabled by ODL) will reduce the miscommunications inherent in messages relayed by voice. Data link and expanded radio coverage will provide direct pilot-controller communications, enabling more timely delivery of clearances by the oceanic service provider and responses from the flight deck. The AIDC will make similar improvements in ground-ground communications.

The ISD controller tools will provide oceanic service providers with further automation support, reducing the amount of time required by manually intensive computations. Along with conflict probe, these capabilities enable service providers to identify potential conflicts and to grant user-preferred routings and requests more frequently.

22.1.1.2 Oceanic Architecture Evolution—Step 2 (2000–2002)

In Step 2, the Oakland and New York centers will refresh the oceanic flight data processing (FDP) hardware. Additionally, reengineering tasks will begin to accommodate additional surveillance and communication sources and to initiate commonality with the en route domain. The HOCSR platform will provide the basis for developing common en route/oceanic processing. Procedural changes and international coordination will enable RVSM to be extended to the Pacific Ocean for equipped aircraft.

Figure 22-5 illustrates the logical oceanic architecture during Step 2.

22.1.1.3 Oceanic Architecture Evolution—Step 3 (2003–2007)

In Step 3, the Oakland and New York centers will incorporate the expanded AIDC message set and automatic dependent surveillance addressable (ADS-A). Figure 22-6 illustrates the logical oceanic architecture during Step 3.

Step 3 enhancements are outlined as follows:

- The expanded AIDC message set will allow oceanic service providers to send, receive, and display additional ground-ground data link messages between FIRs (i.e., coordination; transfer of communications; and emergency, miscellaneous, and general information messages).
- A two-controller access program will provide a fully functional oceanic data link position for an assistant controller in each sector, allowing shared sector responsibilities. The ODL windows will be displayed on both the FID and ISD and will be accessible from either position.
- A full-fidelity trainer will enable oceanic service providers to train in a realistic system simulation environment.
- ADS-A will enable FANS-equipped aircraft to automatically provide periodic position re-

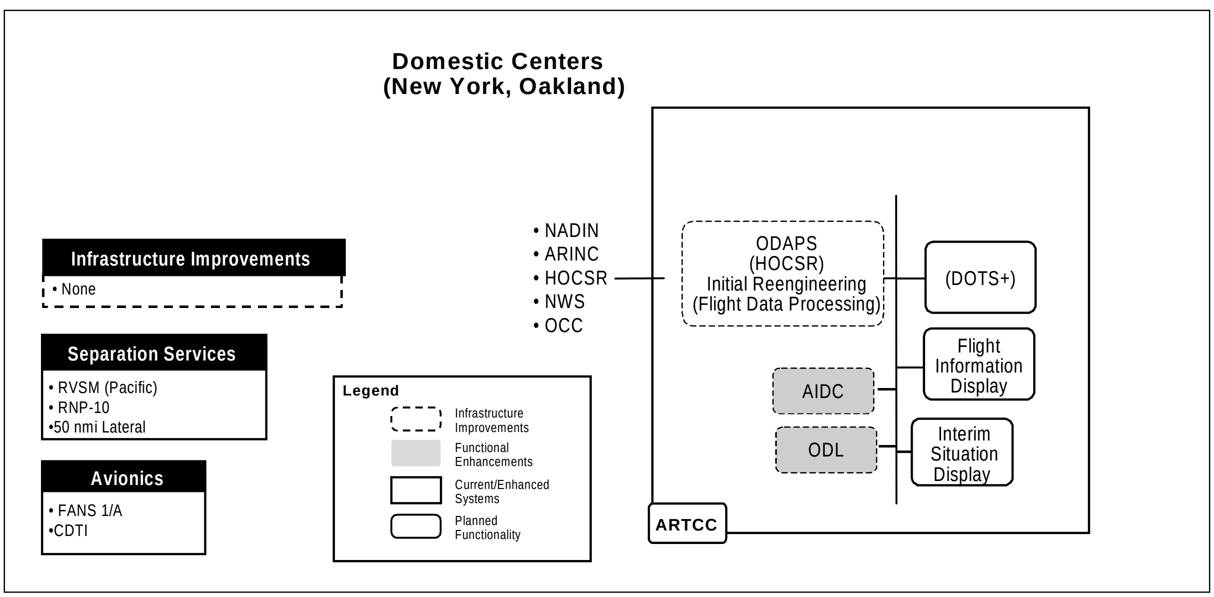

Figure 22-5. Oceanic Architecture Evolution—Step 2 (2000–2002)

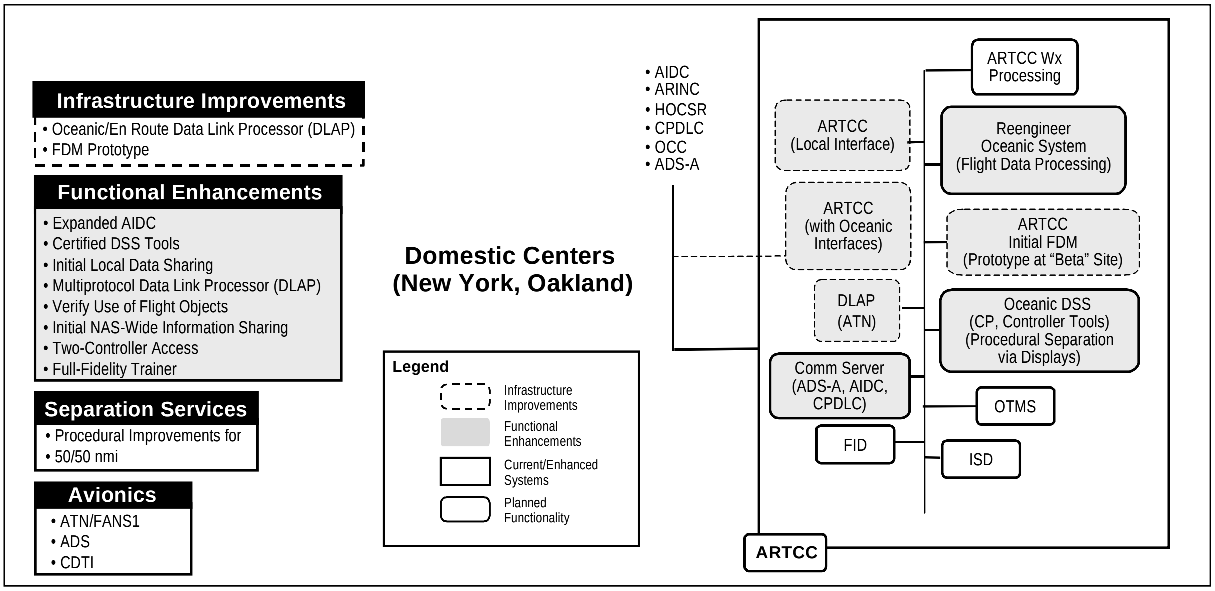

Figure 22-6. Oceanic Architecture Evolution—Step 3 (2003–2007)

ports and event waypoint reports via data link. ADS-A will also include lateral deviation event reports. The waypoint position report will be relayed to oceanic service providers for processing. The oceanic automation will display and update the aircraft position accordingly. ADS-A will support automation functionality that provides distance checking for 50-nmi longitudinal separations, sends distance checking alerts to both the FID and the ISD, and updates to the oceanic flight plan data base. ADS-A position reports will be used by conflict probe in its computations. A common server will support ODL, AIDC, and ADS-B.

- The oceanic architecture allows horizontal separation standards to be reduced to 50/50 nmi, enabling more aircraft to get closer to their wind-optimal routes. Increased frequency and accuracy (GPS-based) of position reports, combined with better controller-pilot communications, helps enable reduced separation standards without adversely affecting safety. ODL, high frequency data link (HFDL), and ADS-A will enable improved ground-air communications and more reliable and frequent surveillance data. DOTS Plus will be renamed the Oceanic Traffic Management System (OTMS) to reflect its expanded scope. The interface between the OTMS and the enhanced traffic management system (ETMS) will help improve coordination between oceanic and domestic traffic flow planning.
- The en route software reengineering efforts will accelerate in Step 3 to address domestic and oceanic commonality (see Section 21, En Route, for a detailed description).
- Ground automation upgrades to display supplementary flight data lists, along with accompanying procedural changes and approved DSS tools, will enable the elimination of paper flight strips.

Figure 22-6 shows the implementation of local information services at Oakland and New York Centers that will incorporate oceanic-unique applications.

A flight data management (FDM) prototype will be deployed at one ARTCC. When the FDM is operational, it will replace the existing flight data processing capability. The FDM prototype will be run in parallel with the existing FDP and serve as an engineering test bed. The FDM expands the existing ODAPS FDP capabilities by enabling the processing of the flight object (see Section 19). This development will enable implementation of a common FDM to support all domains. In brief, a flight object will contain information about a flight (planning through post-flight archiving and analysis) and will be accessible to all FAA service providers and authorized NAS users.

FANS-1/A two-way data link (TWDL) communications, ADS-A, and Air Traffic Services (ATS) facilities notification services will be provided and, as user equipage and demand dictate, ATN controller-pilot data link communications (CPDLC) will be provided. At this time, some oceanic and en route data link processing capabilities will be merged in the Data Link Applications Processor (DLAP). With the initiation of an oceanic communications interface into DLAP, ATN services can begin to be supported in oceanic airspace via DLAP. Aircraft equipped with data link applications, such as TWDL/CPDLC, will be flying in domestic en route airspace, as well as oceanic. Much of the communications software (e.g., FANS-1/A, ATN) needed for the ground systems will be common to both domains.

DLAP will provide multi-protocol and multi-application support for data link communications to aircraft flying in both oceanic and en route airspace. DLAP will mask the application differences from aircraft with different types of data link equipage and will present data link messages to the oceanic automation system in one common format for each application. The oceanic systems, therefore, will only have to include one version of each application (TWDL, ADS-A, and ATN), even though multiple airborne versions of each application are being supported.

Two-controller access provides oceanic controllers with the capability to more evenly distribute the workload associated with reducing separation minima and handling data-link-equipped aircraft during peak-traffic times. The transition to "stripless" operations and the corresponding reduction in controller workload will enable oceanic service providers to meet expected increases in demand. Service providers will use visual displays and decision support tools to monitor the traffic situation and to separate traffic. They will do more strategic planning and grant more user preferences and requests. During this time frame, additional procedural improvements will be considered to allow limited self-separation procedures, such as in-trail station-keeping and lead climb/descent.

The expanded AIDC message set will provide improved coordination between the oceanic facilities and other international FIRs. The data link support for both FANS and ATN will take advantage of improved avionics and significantly improve ground-air communications. The common oceanic en route data link platform will facilitate seamless aircraft transitions and data transfers between the two domains.

22.1.1.4 Oceanic Architecture Evolution—Step 4 (2008 and Beyond)

Figure 22-7 illustrates the logical oceanic architecture in this step. The evolution of oceanic and offshore systems to a common hardware and soft-

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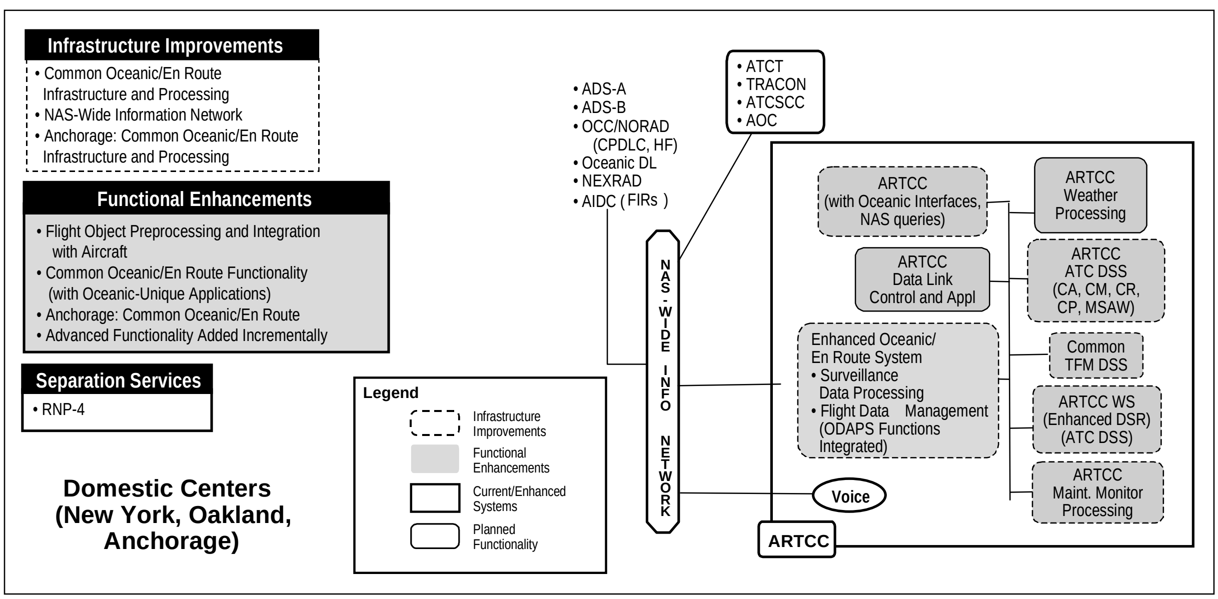

Figure 22-7. Oceanic Architecture Evolution—Step 4 (2008 and Beyond)

ware infrastructure with en route and terminal will be completed in Step 4. Oceanic operations at the Oakland, New York, and Anchorage centers will depend on the acquisition of the common enhanced oceanic en route system. An FDM will be implemented at all three sites, replacing the existing FDP. A common surveillance data processor for the en route, oceanic, and terminal domains will be implemented at each site with domain-specific modifications. The ISD and FID functionality will be integrated into the enhanced DSR workstation, which becomes the common ARTCC workstation. It is assumed that the enhancements made to the DSR during Step 3 of the en route architecture evolution will enable it to support oceanic requirements. A common ARTCC infrastructure will support common and unique oceanic and en route enhanced weather, decision support system, and maintenance applications. This common, modern infrastructure will provide the ground-based platform needed for developing many of the advanced functional enhancements (see Section 21, En Route).

Oceanic communications will continue to migrate from voice communications to data communications. While data communications becomes the primary means of communications, oceanic will continue to support a mixed equipage environment. Increased use of ADS, CPDLC, and AIDC will continue to reduce the need for manual coordination. The ability to communicate trajectory and route information (via CPDLC or TWDL) will enable increased granting of user-preferred routes. ADS-A will be integrated with an advanced conflict probe tool tailored for oceanic use. (see Section 17, Communications).

The NAS-wide information network will be structured to conform to NAS-wide data standards; to incorporate multilevel access control and data partitioning; to provide data security and allow real-time data access via queries; and to assume all data-routing and distribution functions, including data link. Planned functional enhancements, added incrementally to the system, may be able to support even further reductions in separation standards. These would include advanced functionalities, such as dynamic sector boundaries, conflict resolution, and 4-dimensional trajectories.

Expanded collaborative decisionmaking would enable further sharing of separation responsibility between the oceanic service provider and the flight crew. The pilot's ability to support climbs, descents, and crossing and merging routes will be supplemented by uplinked conflict probe information and display of more traffic and weather data. The oceanic service provider's ability to predict conflicts will be supplemented by pilot-intent information downlinked from the aircraft. Common TFM decision support tools will further improve coordination between oceanic and domestic facilities.

The full NAS-wide information network implementation will provide a uniform data format between oceanic and the en route and terminal systems. The ICAO message set will be supported and data communications interfaces will exist with all other equipped FIRs. Data link communications will be standardized, resulting in improved coordination and seamless interfacility transitions.

22.1.2 Offshore Architecture Evolution

The current offshore oceanic ATC systems in Anchorage, Honolulu, San Juan, and Guam have partial radar coverage. The Anchorage and Honolulu TRACONs are not part of this domain and are discussed as part of the terminal architecture. The offshore facilities use the Microprocessor En Route Automated Radar Tracking System (MicroEARTS) for radar data processing of domestic and oceanic traffic wherever radar surveillance is available. The MicroEARTS are automated primary and beacon radar tracking and display systems whose functional capabilities are essentially the same as the terminal area ARTS IIIA radar data processing system, with the additional capability of employing both short- and long-range radar.

Table 22-3, Offshore Evolution Events, summarizes the major events that will occur at each offshore site as it evolves toward commonality with either the en route or terminal domain.

The following paragraphs present the offshore architecture evolution in more detail. Architecture diagrams show the content of each step in a logical or functional representation without any intention of implying a physical design or solution.

Table 22-3. Offshore Evolution Events

Step	Anchorage	Honolulu	San Juan	Guam
1. (1998–1999)	DOTS+ H/W replacement DOTS+ functionality CPDLC MicroEARTS	OFDPS-R (HOCSR) with OFDPS software MicroEARTS	Current system (Miami patch) MicroEARTS RDP	Current system (Manual FDP) MicroEARTS RDP
2. (2000–2004)	OCS rehost/replacement MicroEARTS upgrade DSR workstation ARTCC local information services ADS and data fusion	Additional HOCSR STARS/P3I Terminal controller workstation Terminal local information services ADS and data fusion	Terminal controller workstation Local information services ADS and data fusion	STARS/P3I
3. (2005–2007)	ARTCC local information services upgrade NAS-wide information network	Local information services upgrade NAS-wide information network SDP	STARS/P3I Local information services upgrade SDP NAS-wide information network	Terminal controller workstation ADS and data fusion Local information services upgrade SDP NAS-wide information network
4. (2008 and beyond)	Common infrastructure with en route	Common infrastructure with terminal	Common infrastructure with terminal	Common infrastructure with terminal

22.1.2.1 Offshore Architecture Evolution—Step 1 (Current–1999)

Figure 22-8 depicts Step 1 of the offshore architecture for the four offshore sites: Anchorage, Honolulu, San Juan, and Guam.

Anchorage

Anchorage uses a unique flight data processing system—the offshore computer system (OCS). OCS processes oceanic flight data and implements its own version of data link for FANS-equipped aircraft in Anchorage ARTCC airspace, including offshore and oceanic sectors. OCS also provides flight data to the MicroEARTS radar data processor. An existing AIDC prototype system will become operational to support a ground-ground data link with other international FIRs. The sector layout at Anchorage will also include a DSR workstation that is connected to the MicroEARTS, which will replace the current radar display. While Anchorage will be using the DSR common console hardware (driven by the MicroEARTS and the OCS), it will not be using the DSR software.

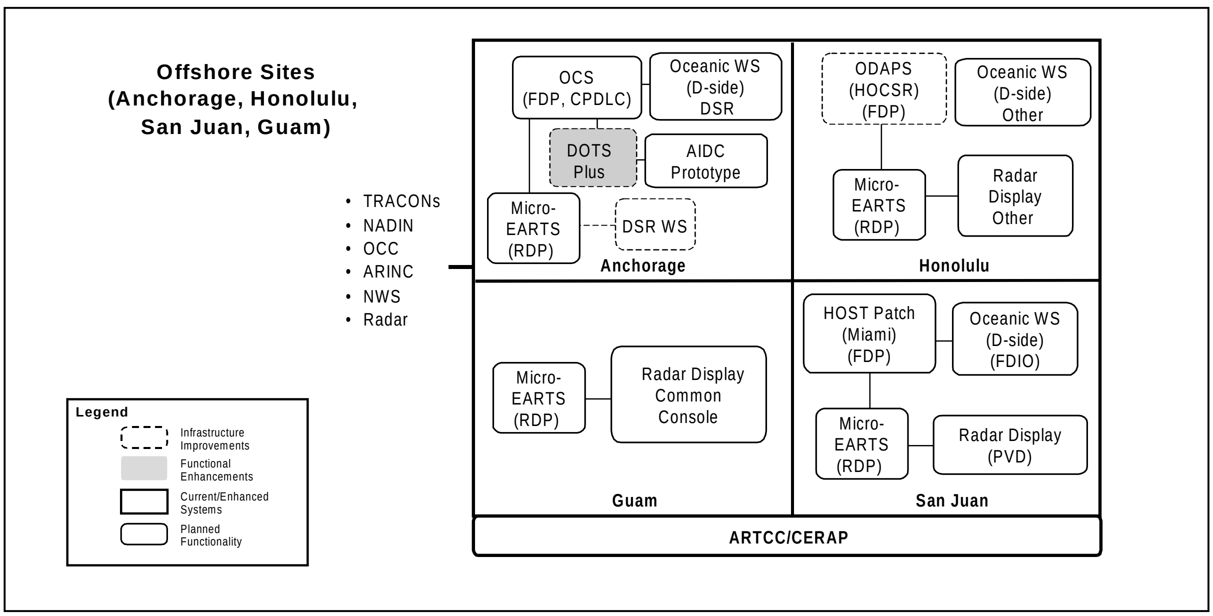

Figure 22-8. Offshore Architecture Evolution—Step 1 (Current–1999)

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Anchorage (like New York and Oakland) also has the automated planning tool, DOTS Plus. DOTS Plus implements track generation and track advisor functions and interfaces with the National Airspace Data Interchange Network (NADIN) for the exchange of track information and aircraft position reports. Scheduled DOTS Plus improvements include hardware replacement and functional enhancements, such as improved weather data, elimination of duplicate message feeds, remote monitoring and software maintenance, and an enhanced GUI.

Anchorage implemented procedures to support reduction to 50 nmi lateral separation for RNP-10 aircraft in the North Pacific Ocean (NOPAC) in April 1998.

Honolulu

In Honolulu, the CERAP uses the Offshore Flight Data Processing System (OFDPS), which is based on modified ODAPS software and is interfaced to a MicroEARTS radar data processor. An OFDPS communications system provides a channel for external interfaces to communicate with OFDPS. The MicroEARTS system, commissioned in January 1998, provides new controller workstations. The OFDPS will be rehosted as part of the En Route HOCSR program, so the HOCSR hardware will be using existing OFDPS application software during this period. (See Section 21, En Route).

San Juan

In San Juan, the CERAP obtains flight data information remotely from the Miami ARTCC (Miami patch), which is transmitted to the replacement flight data printers (RFDPs). San Juan uses the plan view display (PVD) for MicroEARTS controller positions. San Juan commissioned the MicroEARTS system in early 1998.

Guam

Guam currently uses MicroEARTS with common consoles that function as situation displays at each sector. (MicroEARTS was commissioned in March 1997.) Flight plans are received over an aeronautical fixed telecommunications network (AFTN) circuit, and flight strips are printed using a PC-based program. All flight plans are manually entered into MicroEARTS, and all flight data processing is done manually by the controllers. No new improvements are scheduled prior to Step 2.

22.1.2.2 Offshore Architecture Evolution—Step 2 (2000-2004)

Figure 22-9 depicts Step 2 of the offshore architecture for the four offshore sites.

Anchorage

Due to aging equipment, the OCS will be rehosted (OCS-R) onto a more modern platform that includes a reengineered flight data processor that is based upon the existing OCS software. MicroEARTS functionality may be upgraded with ADS-A, ADS-B, data fusion, and improved weather data as a part of the Safe Flight 21 and Capstone demonstration programs. This ADS-B and data fusion capability will be needed to support objectives of these programs. Information sharing will be implemented via the initial ARTCC local information services and will incorporate unique local interfaces.

Honolulu

An additional HOCSR will be deployed to support the transition from the CERAP's present Diamond Head location. The existing HOCSR will be maintained as a backup during the transition period. After the relocation, the MicroEARTS will be replaced by STARS and terminal controller workstations. The STARS functionality will be upgraded to coincide with the STARS preplanned product improvements (P^3I) (see Section 23, Terminal). Information sharing will be implemented via the initial local information services and will incorporate unique local interfaces.

San Juan

The Miami patch for the San Juan FDP process will remain unchanged during this period. Information sharing will be implemented via the local information service and will incorporate unique local interfaces.

Guam

The STARS with the terminal controller workstations will replace the existing MicroEARTS system and common consoles. The STARS functionality will be upgraded to coincide with the STARS P^3I (see Section 23, Terminal). Infor-

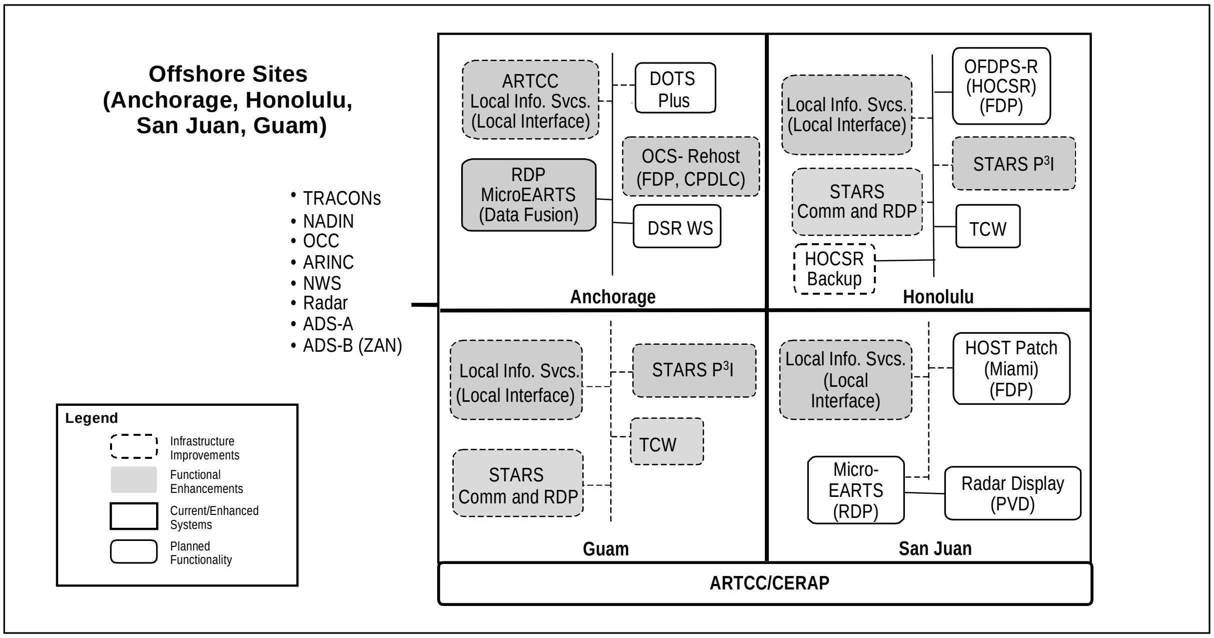

Figure 22-9. Offshore Architecture Evolution—Step 2 (2000–2004)

mation sharing will be implemented via the local information services deployed at Guam and will incorporate unique local interfaces.

22.1.2.3 Offshore Architecture Evolution—Step 3 (2005–2007)

Figure 22-10 depicts Step 3 of the offshore architecture for the four offshore sites.

Anchorage

The OCS-R will continue providing FDP functionality. The ARTCC local information services at Anchorage will be upgraded and unique oceanic interfaces will be incorporated. The local information services will provide the capability for a data repository, in accordance with standards developed for the NAS-wide information network (see Section 19, NAS Information Architecture

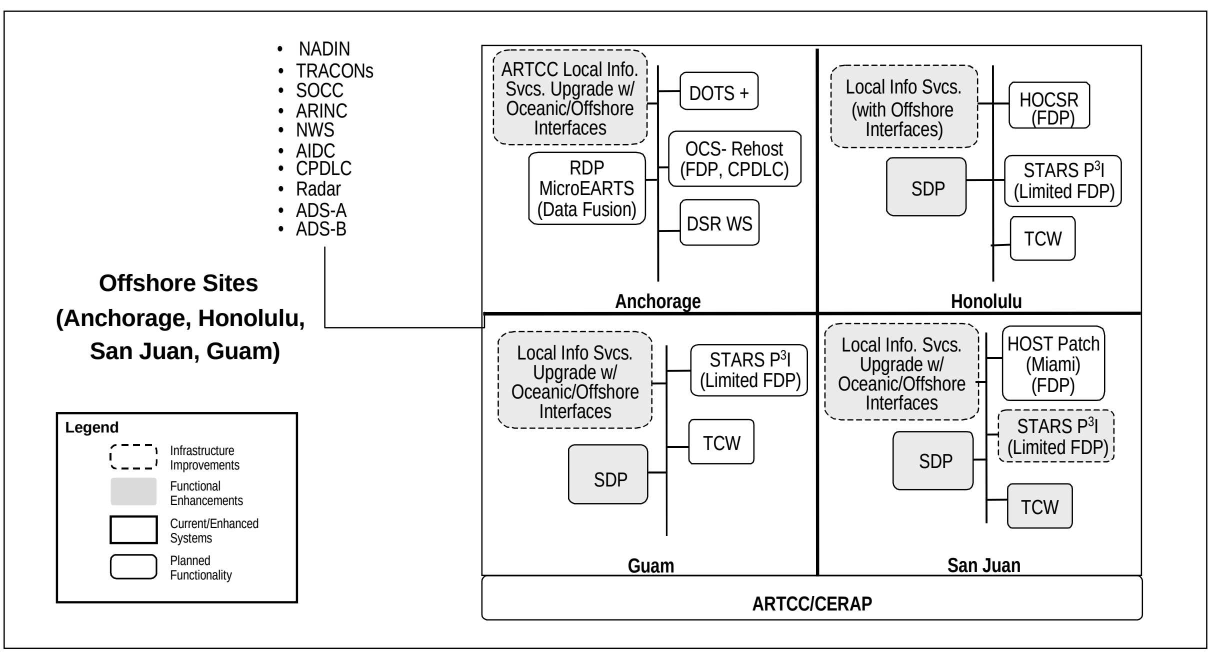

Figure 22-10. Offshore Architecture Evolution—Step 3 (2005–2007)

and Services for Collaboration and Information Sharing), that will enable the sharing of common information between FAA facilities.

Honolulu, San Juan, and Guam

San Juan's MicroEARTS system will be replaced by the STARS and the terminal controller workstation (TCW). The STARS functionality will be upgraded to coincide with the annual deployment of STARS P³I enhancements (see Section 23, Terminal). The common reengineered surveillance data processor (SDP) will be deployed. Limited FDP capabilities will also be provided in STARS during this period. Upgraded local information services with unique offshore interfaces will be deployed along with the NAS-wide information network.

22.1.2.4 Offshore Architecture Evolution—Step 4 (2008 and Beyond)

Figure 22-11 depicts Step 4 of the offshore architecture for the four offshore sites.

Anchorage

This step initiates the evolution from the MicroEARTS/OCS-R-based oceanic flight data management, surveillance data processing, and initial oceanic ATC decision support systems to more advanced functionality and a common infrastructure with en route. The goal is to achieve infrastructure commonality (e.g., common hardware and system software). The applications software will be common where appropriate but will also comply with the domain unique requirements necessary for operational suitability**.** The Anchorage system will have the architecture and capabilities described in Step 4 of the oceanic architecture evolution (see Section 22.1.1.4).

Honolulu, San Juan, and Guam

In this step, Honolulu, San Juan, and Guam will evolve from offshore site domains to an infrastructure common with the terminal domain. This step will fully implement electronic flight data management by using flight objects and the NAS-wide information network. The common infrastructure will include flight data management (FDM), surveillance data processing, and initial TRACON/offshore automation decision support systems. The goal is to achieve infrastructure commonality (e.g., common hardware and system software). The applications software will be common where appropriate but will also comply with the domain unique requirements necessary for operational suitability (see Section 23, Terminal).

22.2 Summary of Capabilities

Oceanic operational improvements are centered around improved automation systems; procedural improvements; and advanced communications, navigation, and surveillance capabilities. In the near term, RVSM will enable increased airspace

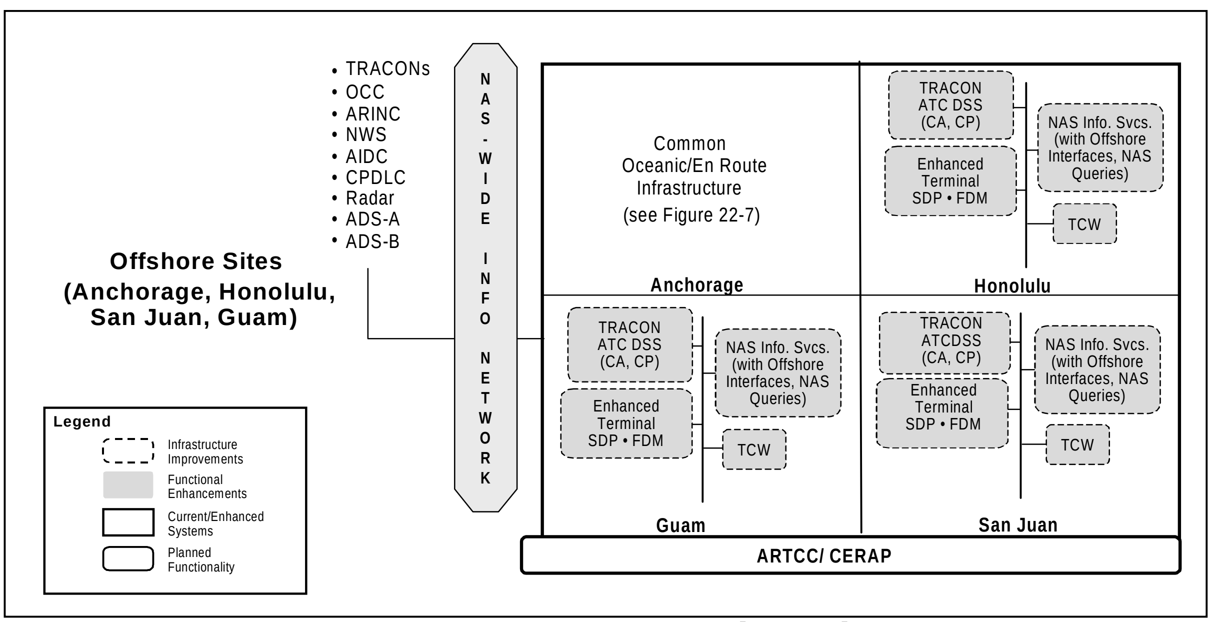

Figure 22-11. Offshore Architecture Evolution—Step 4 (2008 and Beyond)

capacity, and ODL and DOTS Plus will support dynamic rerouting and separation verification. Aircraft equipage and procedural improvements will allow the separation standards to be reduced to 50 nmi lateral in more oceanic airspace.

Automation enhancements, multi-sector ODL, ADS-A, and AIDC will enable separation standards to be reduced to 50 nmi lateral and 50 nmi longitudinal in some oceanic airspace and then eventually in all oceanic airspace. Procedural improvements, in conjunction with separation from the glass and stripless operations, may allow separation standards to be reduced beyond 50/50 nmi in some oceanic airspace. Sharing common information between oceanic and domestic sites and international FIRs will improve coordination.

Migration to an enhanced en route/oceanic automation system with advanced decision support tools and dynamic sector boundaries will support the capability for further reduction of oceanic separation standards.

The NAS-wide information network will facilitate sharing control data for collaboration between national and international air traffic service providers to determine the daily airspace structure (based on weather, demand, user preferences, and equipage), to identify and mitigate capacity problems, and to ensure seamless transition across FIR boundaries. The NAS-wide information network will improve collaborative decisionmaking between FAA and users—as will timely data link sharing of information between the oceanic service provider and the cockpit. Figure 22-12 depicts the evolution of oceanic and offshore operational capabilities.

22.3 Human Factors

Human factors methods, principles, and practices will be applied during the oceanic evolution process. Understanding the human factors issues associated with the oceanic implementation of ADS, improved navigation tools, real-time communications, and automated data exchange between pilot and oceanic service provider via data link is required. Displays and decision support tools will support the goals of increasing flexibility and efficiency through implementing dynamic rerouting (e.g., step climbs, cruise climbs, and optimum altitudes) and dynamic management of route structures (i.e., flex tracks and user-preferred profiles).

To achieve these goals requires a better understanding of which decisions to support and what specific functions DSSs will perform. Furthermore, to integrate the system across domains, boundaries, and authorities will require an in-depth understanding of the communication process between controllers in the system and how this process can be automated.

The human factors aspects of this new process will be critical, since the improved communication level and less rigid structure in the airspace will need new methods for presenting information to controllers and other users.

The primary elements of the required information to make this transition include the definition of

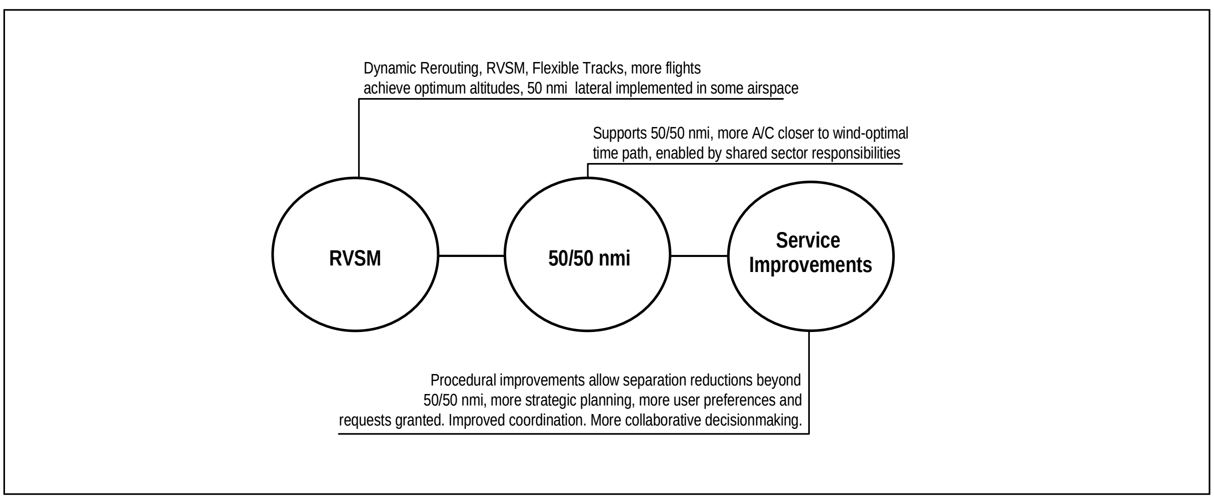

Figure 22-12. Oceanic and Offshore Operational Improvements

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service provider and user functions, decision processes, information requirements, and communication processes that are necessary to accomplish the goals. This information makes it possible to integrate flight-strip information on the primary oceanic display in a manner that allows for the elimination of paper flight strips.

Human factors guidance will be provided in the area of oceanic automation and decision support systems to ensure that they will provide the anticipated user and service provider capabilities. The DSS must detect deviations and account for required oceanic procedural separation rules. Issues requiring resolution include accuracy and sensitivity of the algorithms versus the false alarm rates that are acceptable to service providers. Tools must be developed to help system designers understand what decisions should be supported, the best means to deliver the information to the service provider, and how to elicit knowledge from experts during the algorithm development process.

Using oceanic data link to issue altitude assignments, frequency changes, clearances, and weather hazard alerts will contribute to efficiency. There are human factors issues to be resolved regarding the ability of oceanic service providers to ensure that the correct messages are sent, properly received, and acknowledged. Human factors research needs to be conducted to refine and augment the human engineering guidelines for system development in data link communications to ensure that providers and users sustain or enhance their current level of situation awareness using data link communications during oceanic operations.

The process of TFM in future oceanic operations will depend heavily on collaborative decisionmaking. That is, information will be shared between service providers and users so that both parties can optimize the process of flight scheduling, routing, and maneuvering. Human factors research is required to develop alternative methods for interaction between users and service providers to enhance oceanic flexibility. The research needed encompasses development of analytical tools to evaluate the human factors aspects of how collaborative decisionmaking (CDM) will be conducted from the standpoint of communication and information transfer between users and oceanic service providers.

Inclusion of the flight deck in some shared separation responsibility requires additional human factors research to address the issues of flight deck information requirements and cross-system integration. The issue of responsibility (e.g., specific procedures and rules of the road) will be addressed and resolved before shared separation decisionmaking/responsibility occurs on the flight deck. A concerted effort will be directed at determining the capabilities and limitations of pilots and controllers so that it will be possible to change the oceanic concept of operations in a manner that results in the requisite increase in efficiency and safety.

Considerable human factors guidance is required for successful transition between stages of the oceanic system evolution process. This includes implementing data link communications and processes and the transition from procedural separation using paper strips to procedural separation using displays with integrated DSS tools.

22.4 Transition

The oceanic and offshore transition is shown in Figure 22-13.

22.4.1 Oceanic Elements

The principal elements of the transition to the oceanic architecture are as follows:

- DOTS Plus implemented at Oakland and New York
- ODL, ISD controller tools, and initial AIDC deployed at Oakland and New York
- ODAPS hardware at Oakland and New York rehosted onto the same type of platform as the Host sustainment platform (HOCSR)
- ADS-A software deployed at Oakland and New York; communications server supports ODL, ADS-A, and AIDC

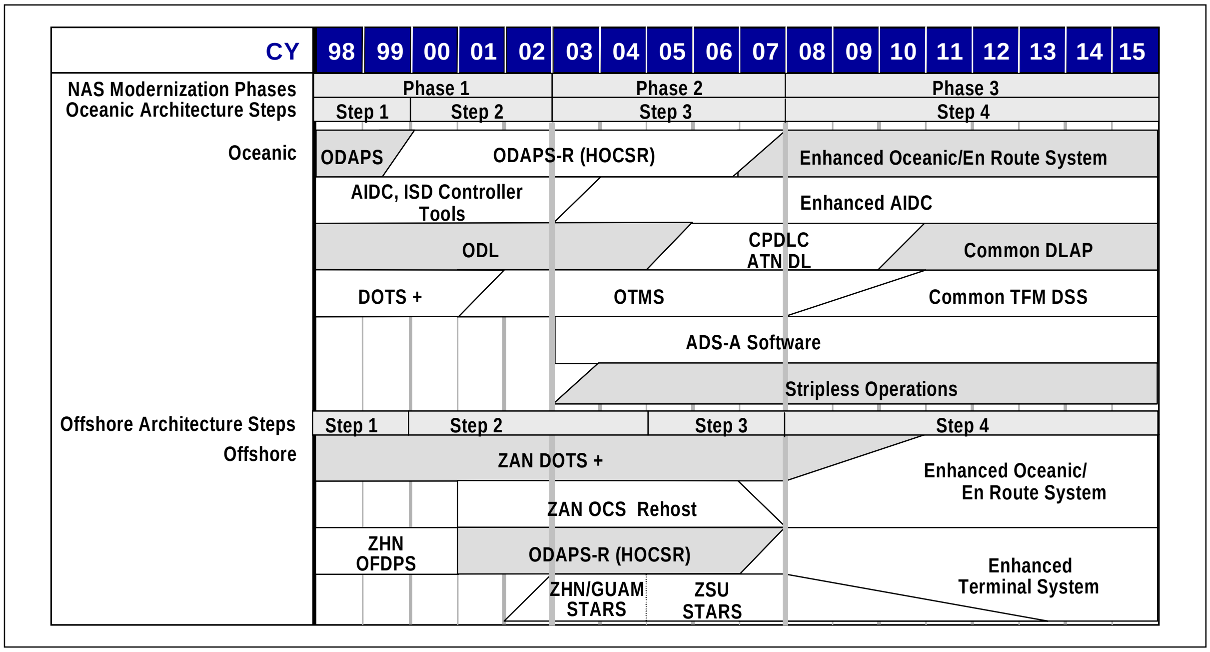

Figure 22-13. Oceanic and Offshore Transition

- OTMS functionality upgrades at Oakland and New York
- TCA, Full-Fidelity Trainer, Enhanced AIDC
- Transition to stripless operations at Oakland and New York
- FDM prototype deployed as engineering test bed
- Common DLAP supporting oceanic and domestic data link
- Introduction of NAS-wide information network
- Common oceanic/en route system deployed at Oakland, New York, and Anchorage
- Common terminal/offshore system deployed at Honolulu, San Juan, and Guam
- Functional enhancements are implemented to fully satisfy mid-term CONOPS.

22.4.2 Offshore Elements

- The principal elements of the transition to the offshore architecture are:
- DOTS Plus implemented at Anchorage
- OFDPS replaced at Honolulu (HOCSR)
- OCS replaced at Anchorage
- STARS deployed at Guam and Honolulu
- Introduction of Local Information Services at offshore sites
- STARS deployed at San Juan
- Introduction of NAS-wide information network at offshore sites
- Common terminal infrastructure for Honolulu, San Juan, and Guam
- Common oceanic/en route system for Anchorage
- Functional enhancements are implemented to fully satisfy mid-term CONOPS.

22.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for oceanic and offshore architecture from 1998 through 2015 in constant FY98 dollars are presented in Figure 22-14.

22.6 Watch Items

A current study is investigating a number of innovative alternatives to meet oceanic user needs and FAA commitments to reduce separation standards. This effort focuses on an FAA/industry partnership to deliver benefits earlier than is cur-

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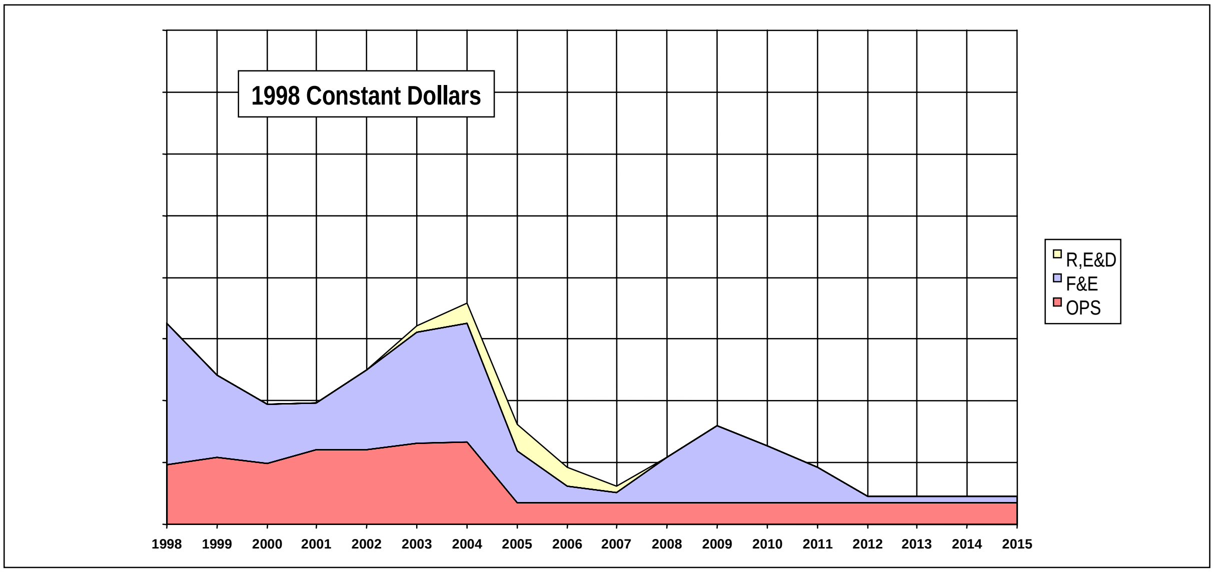

Figure 22-14. Estimated Oceanic and Offshore Costs

rently affordable with FAA funding. System capacity will not keep pace with growth in traffic volume until improvements are made to the oceanic ATC system.

The oceanic and offshore architecture evolution will require new procedures, regulations, standards, and certification of all systems whose failure could affect flight operations safety. New operating procedures will be required for reduced separation standards, flexible routing, and increased use of automated information exchange between aircraft, service providers, and international FIRs. Standards for message formats and content must be generated and agreed upon internationally.

Implementing oceanic capabilities and achieving the oceanic and offshore functionality and subsequent operational benefits described in the architecture depends on adequate funding, which has been and continues to be a problem. Thus, successful implementation of the oceanic architecture will depend on the success of related activities in other domains (described below).

- Demonstrate the ability of ground automation systems to process improved surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS; to merge these data with radar data and pilot position reports; and to display this information to controllers with an acceptable computer-human interface (CHI)

- Timely deployment of ODAPS, OFDPS, and OCS hardware supportability solutions that solve the infrastructure replacement problems in the near term and provide a bridge to the new capabilities of the evolving systems necessary to meet future requirements

- The budget for incorporating some of the future functionality is related to development of common algorithms to provide this functionality across domains where appropriate. Areas where common functionality across domains is anticipated are:

  – Surveillance processing and ADS data fusion in the terminal, en route, oceanic, and surface domains

  – Weather services

  – Flight object processing (FDM)

  – Functionality in some ATC DSS and safety-related tools.

23 TERMINAL

The primary task of air traffic control (ATC) in the terminal domain is to ensure that aircraft are safely separated and sequenced within the airspace immediately surrounding one or more airports. Terminal automation systems provide the terminal radar approach control (TRACON) facilities with capabilities for controlling arriving, departing, and overflight aircraft and provide tower facilities with terminal radar aircraft situation displays. TRACON facility controllers, with support from a co-located traffic management unit (TMU) (at some high-activity locations), manage the flow of air traffic in the terminal airspace.

The future terminal architecture accommodates the projected air traffic growth through automation enhancements and procedural changes to improve capacity, reduce maintenance costs, and provide the foundation for future enhancements. A combination of ground and airborne automation capabilities will allow flexible departure and arrival routes and reduce and/or eliminate speed and altitude restrictions in the terminal domain. A major driver of the terminal architecture is to lower operations and maintenance costs by evolving toward maximum commonality between offshore and domestic air traffic services.

As described in Section 22, Oceanic and Offshore, the ATC automation systems at offshore sites (Guam, San Juan, and Honolulu) will evolve toward automation systems commonality with the terminal domain. The concept of commonality is that the offshore facilities will evolve to the terminal infrastructure and the applications software as appropriate, but they will also utilize domain- and site-specific capabilities necessary for operational suitability.

The FAA and the Department of Defense (DOD) will replace all of their terminal automation systems in the NAS with the Standard Terminal Automation Replacement System (STARS). STARS is an all-digital system based on an open system architecture.

The terminal architecture will evolve to provide the following enhanced capabilities:

- Improved arrival and departure sequencing based on surface traffic, airline preferences, and traffic flow information
- Integrated display of weather and aircraft positions based on primary/secondary radar, and automatic dependent surveillance (ADS) information
- Conformance monitoring, conflict detection, and conflict probe functionality
- Automated exchange of real-time flight data among aircraft, ATC facilities, airline ramp control, and airline operations centers (AOCs) to support collaboration
- Integration of surface and terminal automation.

These enhancements will allow for improvements such as:

- Reduction and/or elimination of terminal area speed and altitude restrictions
- Flexible departure and arrival route structures and possible reduced separation.

23.1 Terminal Architecture Evolution

The terminal architecture evolves from an infrastructure composed of various FAA and DOD automation systems to a standard infrastructure—STARS. The evolution of STARS includes preplanned product improvements (P^3I) to support enhanced functionality, as well as periodic upgrades to ensure future maintainability and supportability.

During a four-step evolution, the terminal architecture will integrate capabilities that will also satisfy many offshore automation requirements. The following diagrams show each evolutionary step in a logical or functional representation without any intention of implying a physical design or solution.

The STARS deployment program will install systems at 170 FAA and 36 DOD terminal facilities over approximately 6 years. The current equipment (i.e., automated terminal radar system (ARTS IIA, IIE, IIIA, IIIE)) and associated displays and peripherals and the DOD programmable indicator data processor (PIDP)) will be decommissioned. STARS P^3Is will incrementally provide new functionality and enhancements (see Figure 23-1).

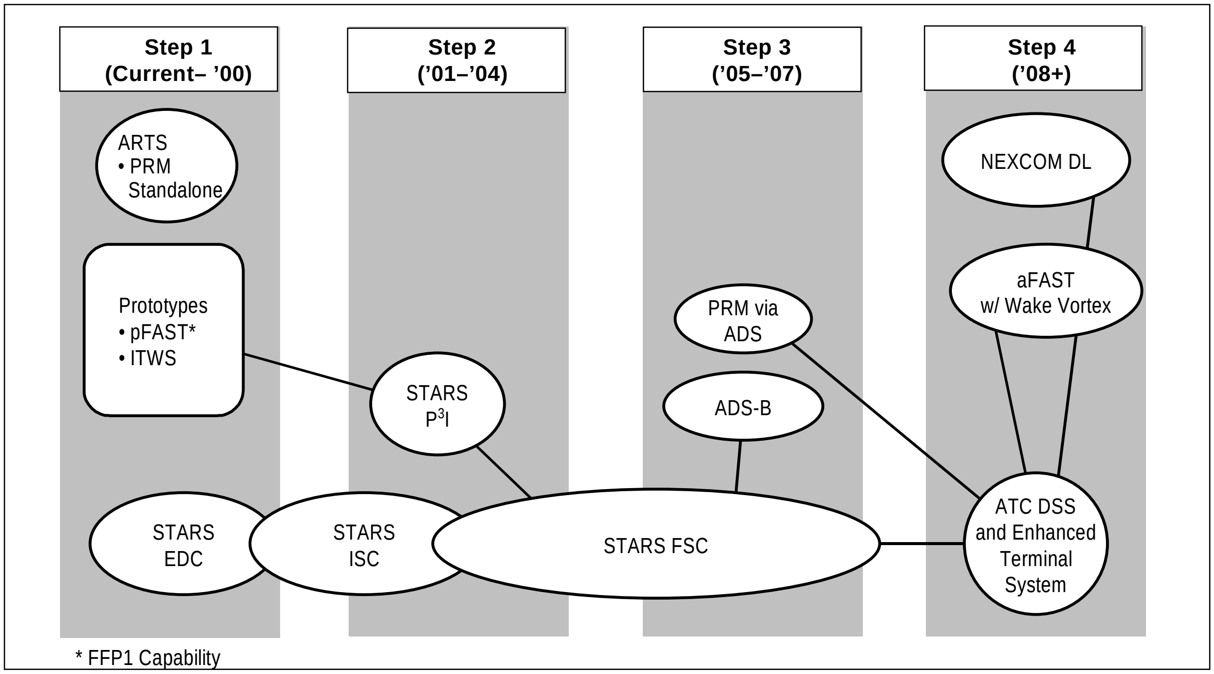

Figure 23-1. Terminal Architecture Evolution

23.1.1 Terminal Architecture Evolution—Step 1 (Current–2000)

In this step, current terminal automation systems will begin to be replaced with more modern systems that provide the foundation for future enhancements (see Figure 23-2). Step 1 consists of the current automation systems and the initial STARS implementation.

Current Automation Systems

The current terminal automation systems consist of computer processing and display systems that are used in conjunction with airport surveillance radars. The current systems used within the TRACON are FAA configurations of the ARTS and the DOD PIDP (collectively referred to as ARTS). ARTS began with the ARTS I in 1964, then evolved into several configurations. The ARTS IIA and ARTS IIE are designed to provide automation support to air traffic controllers at small to medium-sized TRACONs, and the ARTS IIIA and ARTS IIIE are designed for larger TRACONs.

ARTS satisfies the requirements for tracking and identifying aircraft. In addition, the ARTS IIIA, IIE, and IIIE systems provide additional safety functions, such as conflict alert, Mode-C intruder (MCI), and minimum safe altitude warning (MSAW). Conflict alert and MCI are automated safety functions that detect unsafe proximity between aircraft pairs and provide visual and aural alerts to controllers. MSAW detects proximity between tracked aircraft and terrain and/or obstructions and provides controllers visual and aural alerts. ARTS IIA systems are being updated to ARTS IIE in order to provide these safety functions.

ARTS acquires and maintains aircraft identification, predicts future locations and altitudes, displays the information directly to a controller, and transfers the information to the next controller responsible for the aircraft. It associates the transponder code received from the aircraft via the secondary radar surveillance system with the assigned transponder code contained in the flight plan (received from the en route host computer).

ARTS provides TRACON controllers with continuous alphanumeric information on radar and data displays. This information, displayed in a data block, includes the aircraft identity, altitude, the type of aircraft, ground speed, any special equipage of the aircraft, and, if applicable, the emergency status of the aircraft.

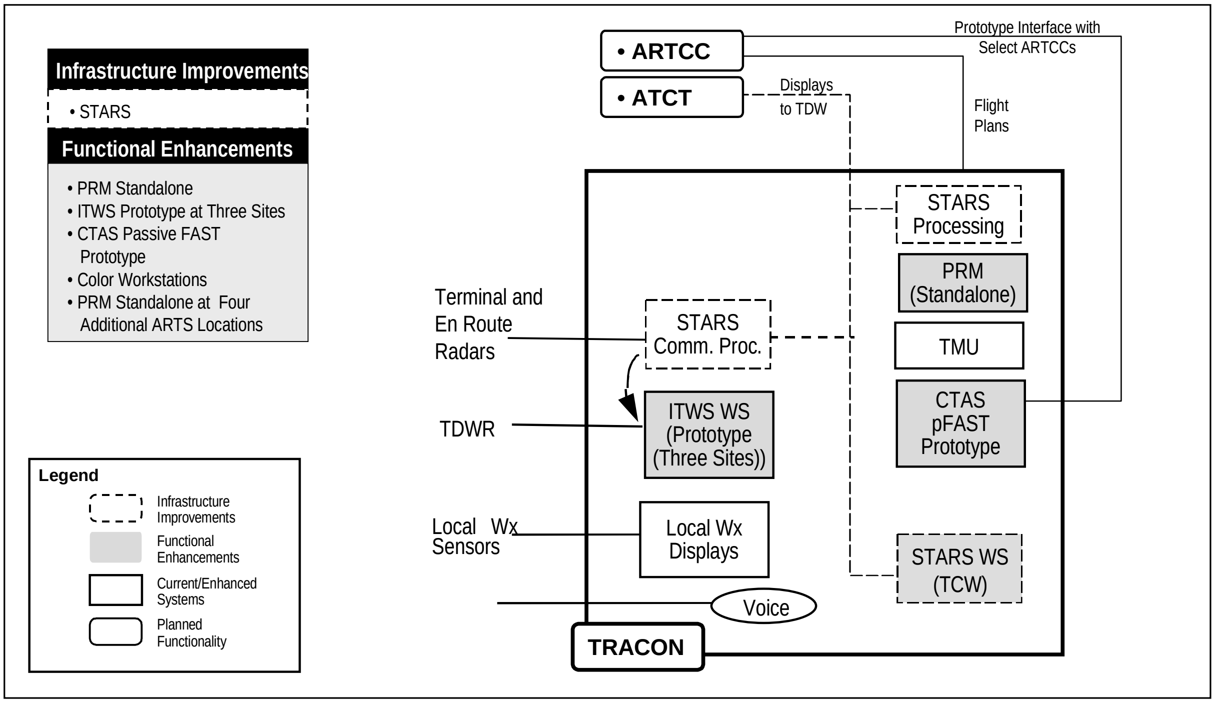

Figure 23-2. Terminal Architecture Evolution—Step 1 (Current–2000)

Specific ARTS versions also support use of the Final Monitor Aid (FMA), Converging Runway Display Aid (CRDA), and Controller Automation Spacing Aid (CASA). FMA monitors aircraft on final approaches to parallel runways and provides controllers visual and aural alerts when approaching aircraft are predicted to enter a nontransgression zone between parallel runways. CRDA and CASA are algorithms and display features that assist controllers in merging arriving traffic into a final approach sequence. CRDA and CASA functionality assists controllers in visualizing the relationships between aircraft on different flight paths in the terminal airspace and adjusting spacing between aircraft to maximize capacity. CRDA is used at airports with converging runways that have straight-in approaches. CASA is used at airports with curved approaches.

The digital bright radar indicator tower equipment (DBRITE) system is a tower display that presents radar/beacon, weather, and ARTS data to tower controllers.

Flight Data Input Output (FDIO) is a separate system that provides a capability for terminal controllers to enter and retrieve aircraft flight plans into and from the en route host computer and to print paper flight progress strips for use by terminal and tower controllers.

Other Current Capabilities

Several other capabilities currently exist or will be introduced into the terminal domain during Step 1.

Air Traffic Management. Within certain high-activity TRACONS, a TMU serves as the interface with the enhanced traffic management system (ETMS), the backbone of the current national traffic flow management (TFM) system (see Section 20, Traffic Flow Management). The TMU provides a projection of aircraft demand for primary airports via the monitor alert functions and the aircraft situation display. Monitor/alert informs the traffic management coordinator when projected traffic flows will exceed capacity and provides a means for adjusting flows in coordination with the Air Traffic Control System Command Center (ATCSCC) and the AOCs.

Center TRACON Automation System (CTAS)/ passive Final Approach Spacing Tool (pFAST). A CTAS/pFAST prototype is in operation at the Dallas-Fort Worth TRACON, interfacing with the ARTS-IIIE. Based on its mature status as a research and development prototype program,

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CTAS/pFAST was selected for deployment at additional sites as a part of Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) to provide early benefits to ATC and NAS users in the terminal domain. pFAST is an automation tool that assists terminal controllers in sequencing and spacing arrival traffic. pFAST integrates radar sensor, flight plan, aircraft performance, and weather data. The pFAST processor algorithms sequence and merge aircraft approaching the airport from different directions. Aircraft are merged into a steady arrival stream, which balances runway utilization, increases traffic-flow efficiency, and helps pilots conserve fuel. pFAST sends the aircraft and sequencing data for display at controller workstations. The pFAST functionality is modular and will be developed in several incremental builds that will progressively increase the tool's sophistication.

Integrated Terminal Weather System (ITWS). ITWS, currently a prototype system at three locations (Dallas-Fort Worth, Orlando, and Memphis TRACONs), functions as a weather server in the terminal domain. ITWS integrates weather from terminal Doppler weather radar (TDWR) and airport surveillance radars (ASRs) for display at terminal facilities. It also provides alerts and short-term forecasts of terminal weather conditions (see Section 26, Aviation Weather).

Parallel Runway Monitor (PRM). PRM allows independent simultaneous parallel approaches under instrument meteorological conditions (IMC) for parallel runways spaced from 3,400 to 4,300 feet. The PRM consists of an electronically scanned surveillance radar with 1-second update and a high-resolution color display. PRM requires track and flight plan data from the terminal automation system. Currently a one-way interface from ARTS to the PRM has been defined.

PRM provides controllers with visual and aural alerts when an approaching aircraft is predicted to blunder into the nontransgression zone between the runways. It was commissioned at Minneapolis-St. Paul in 1997 and St. Louis in 1998 and is scheduled for implementation at three additional terminal facilities (New York (John F. Kennedy Airport), Philadelphia, and Atlanta).

Tower Interface Systems

Two Tower prototype programs, the Airport Movement Area Safety System (AMASS) and the surface movement advisor (SMA), require an interface with the terminal automation system to receive track and flight information.

Airport Movement Area Safety System. AMASS, currently a prototype system at the Detroit and St. Louis airports, will be deployed to 34 airports. It alerts tower controllers to potential aircraft conflicts on the airport surface via audible cautions and warnings and visual information superimposed on the airport surface detection equipment (ASDE)-3 display (see Sections 16, Surveillance, and 24, Tower and Airport Surface).

Surface Movement Advisor. The SMA prototype developed at Atlanta is planned for implementation at selected facilities. The prototype shares information among air traffic, the airlines, and the operations community. However, to provide early benefits to users as part of FFP1 CCLD, SMA has been redefined to provide a form of limited collaborative decisionmaking (CDM) capability. Specifically, initial SMA for FFP1 CCLD will provide aircraft arrival, departure, and airport status information via ARTS to airline ramp control operators (see Section 24, Tower and Airport Surface).

STARS Implementation Phase

Current automation systems will be unable to meet growing traffic demands or readily incorporate new functionality. The FAA needs an open, expandable terminal automation platform that can accommodate current and future needs. STARS will replace the various ARTS systems at FAA TRACONs and PIDP at DOD facilities with modern displays and distributed processing network architectures. STARS will also replace DBRITE with the tower display workstation (TDW) to provide equivalent ATC operational functionality.

STARS provides a standard automation architecture that is scalable across all TRACON facilities. It will reduce costs for software changes, improve software portability and documentation, reduce hardware and software maintenance and training, and provide the capacity for future growth. STARS will also provide color displays for terminal and tower controllers (i.e., terminal controller workstations (TCWs) and TDWs) to increase the amount of information that can be displayed and to improve data discrimination. STARS requires digitized radar data from surveillance systems (see Section 16, Surveillance) to process tracking and will provide multiple radar sensor tracking and mosaic display.

STARS functionality will be delivered in three capability configurations. The early display configuration (EDC) will interface with the existing ARTS via the automation interface adapter (AIA). The ARTS backroom equipment provides the processing capability using STARS displays.

The STARS initial system capability (ISC) and final system capability (FSC) configurations modernize the automation of terminal facilities and provide a single automation solution, while overcoming the deficiencies of the current terminal automation systems. (FSC will not be implemented until Step 2.) STARS also provides an evolutionary path to provide new functionality as it becomes available. FSC will incorporate FMA, CRDA, CASA, and a maintenance interface to the operational control centers (OCCs). The OCC interface will be used for remote monitoring and control of STARS.

23.1.2 Terminal Architecture Evolution—Step 2 (2001–2004)

During this period, deployment of STARS to all FAA TRACONs will continue, as will national deployments of CTAS/pFAST, PRM, AMASS, and ITWS (see Figure 23-3). STARS P^3I planning includes a limited set of FDP capabilities to enhance STARS. STARS will replace the Microprocessor En Route Automated Tracking System (MicroEARTs) systems at two offshore facilities (Honolulu center radar approach control (CERAP) and Guam) (see Section 22, Oceanic and Offshore).

Functionality enhancements to STARS will be provided in a series of "packages." It is anticipated that these packages will be implemented one per year for several years. The first planned package includes interfaces to pFAST, PRM, AMASS, and SMA. These systems, which had been interfaced to ARTS as prototypes, will begin national deployment. The All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX), free-form text, and terminal controller position-defined airspace will also be implemented. Definition of these STARS enhancements follow:

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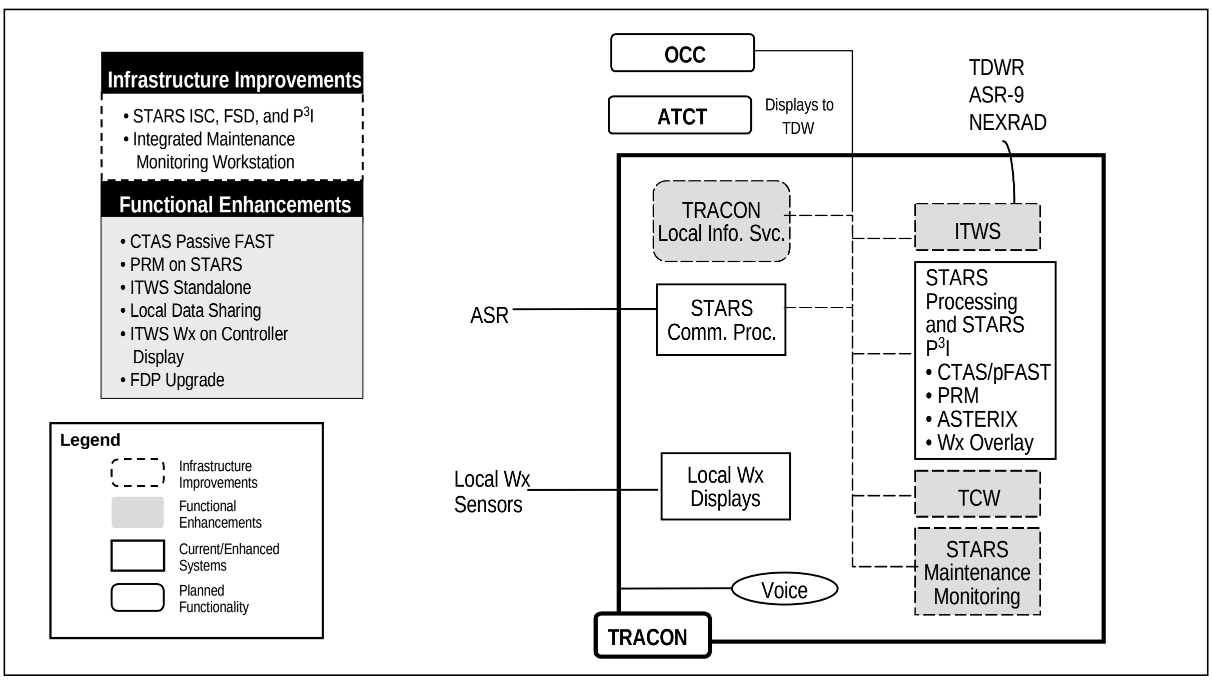

Figure 23-3. Terminal Architecture Evolution—Step 2 (2001–2004)

All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX). This is a digital surveillance message format currently being standardized under the leadership of EUROCONTROL.[1] ASTERIX will permit a sensor to transmit surveillance data with increased precision and a unique aircraft identification code in the target position report. This identification will be used for surveillance processing/tracking and separation assurance function enhancements. ASTERIX will enable other surveillance processing enhancements, such as selective interrogation (SI) and processing automatic dependent surveillance-broadcast (ADS-B) data (see Section 16, Surveillance). ASTERIX will be implemented with the interface to the ASR-11, ATCBI-6, and Mode-S radar systems being procured.

Free-Form Text. This function allows the controller to input and place alphanumeric text anywhere on the STARS TCW/TDW displays. The function replaces handwritten notes that are used during the controller relief briefing. Free-form text is a safety enhancement to ensure information is available and in view of the controller.

Terminal Controller Position-Defined Airspace. This allows the controller to define an airspace (i.e., temporarily restricted airspace) and display it on the TCW/TDW. This capability ensures safe operations in the vicinity of special aviation activities (e.g., parachute jumping) and will facilitate other safety critical operations, such as release of instrument flight rules (IFR) traffic at uncontrolled airports, release of volumes of airspace to other sectors, and providing reminder messages for procedures temporarily changed due to equipment outages or weather conditions.

Candidates for other P^{3}I packages to be implemented during this period include:

Automated Barometric Pressure Entry (ABPE). Currently, controllers manually enter the barometric pressure reference used by the terminal automation system. The current setting is obtained from direct-reading instruments or digital altimeter setting indicators (DASIs) or the nearest weather reporting station. The altimeter setting affects an aircraft's altitude displayed to the controller. ABPE adds a STARS interface to the Automated Surface Observing System (ASOS) (or the DASI) for automated input of local barometric pressures, thereby reducing controller workload and the possibility of data entry error.

STARS/STARS Interfacility Interface. Currently, the interface between terminal automation systems is via the en route Host computer system. STARS-to-STARS interfacility communications will allow a STARS facility to exchange data directly with up to seven other STARS facilities. This change will increase operational and technical efficiency and reduce the Host workload.

Flight Data Input/Output Integration Into STARS. The current FDIO in the TRACON facilities will be replaced. Integrating FDIO into STARS will include FDIO keyboard and display functionality at the TCW and a flight strip printer.

Surveillance Processing Enhancements. STARS inherent capabilities allow use of enhanced surveillance algorithms, information, and processing functions. These improved surveillance capabilities depend on the ASTERIX message format described above. The implementation of ASTERIX enables tracking, conflict alert, and Mode-C intruder alert algorithms to be improved due to increased precision of position reporting, the surveillance file numbers correlating targets to tracks, and the time stamps for target reports.

ITWS Weather on Controller Displays. Initially, ITWS will be a stand-alone system with the weather data available to terminal controllers on separate displays. Later, ITWS weather information will be displayed on STARS. This capability will provide convective and hazardous weather detection and prediction information (from ITWS outboard processing) directly at controller positions, thereby increasing efficiency and safety. At sites that are not receiving ITWS, the ASR-9 weather system processor (WSP) will be interfaced to STARS to display windshear information on the TCW.

Traffic Management Interface Enhancements. The ETMS upgrade is a two-way interface that will permit display of ETMS data on the TCW.

1. The European Organization for the Safety of Air Navigation.

Another candidate functionality for implementation (depending upon funding) during this time period is:

Flight Data Processor (FDP) Upgrade. Currently, flight data are processed by the en route Host computer at the ARTCCs. The offshore sites are not within ARTCC airspace, and thus are not supported by this FDP capability. A limited set of FDP capabilities is required for STARS to fully replace the current MicroEARTs and unique local FDP systems at Honolulu, San Juan, and Guam (see Section 22, Oceanic and Offshore). Also, FDP capabilities in STARS will reduce dependence on the en route automation system.

23.1.3 Terminal Architecture Evolution—Step 3 (2005–2007)

STARS will be delivered to a third offshore facility (San Juan) during this step.

Electronic flight data management (FDM) will be introduced through a prototype flight object processor. TRACON data will be routinely available throughout the NAS via local information sharing and the NAS-wide information network. (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing). Real-time surveillance data will be distributed from the sensors to TRACONs and from the TRACONs to other ATC facilities.

Introducing aircraft and surface vehicle ADS-B information processing and surveillance data fusion will allow enhancements to the terminal tracking and safety functions. Surveillance data processing of aircraft and surface vehicles will facilitate integration of terminal and tower data from a single automation source such as STARS (see Figure 23-4).

Surveillance Data Processor (SDP)

As secondary radar systems with selective interrogation (SI) capability are implemented, ground automation system changes will be incorporated to effectively interface with these systems.

TRACON automation will permit acceptance and processing of ADS-B position reports and the integration and fusion of ADS-B data with radar data. TRACON automation processing will be expanded to integrate terminal radar and surface surveillance data, including ground vehicles operating on the airport surface movement area. The end result is the integration of airborne and surface surveillance information on the tower displays.

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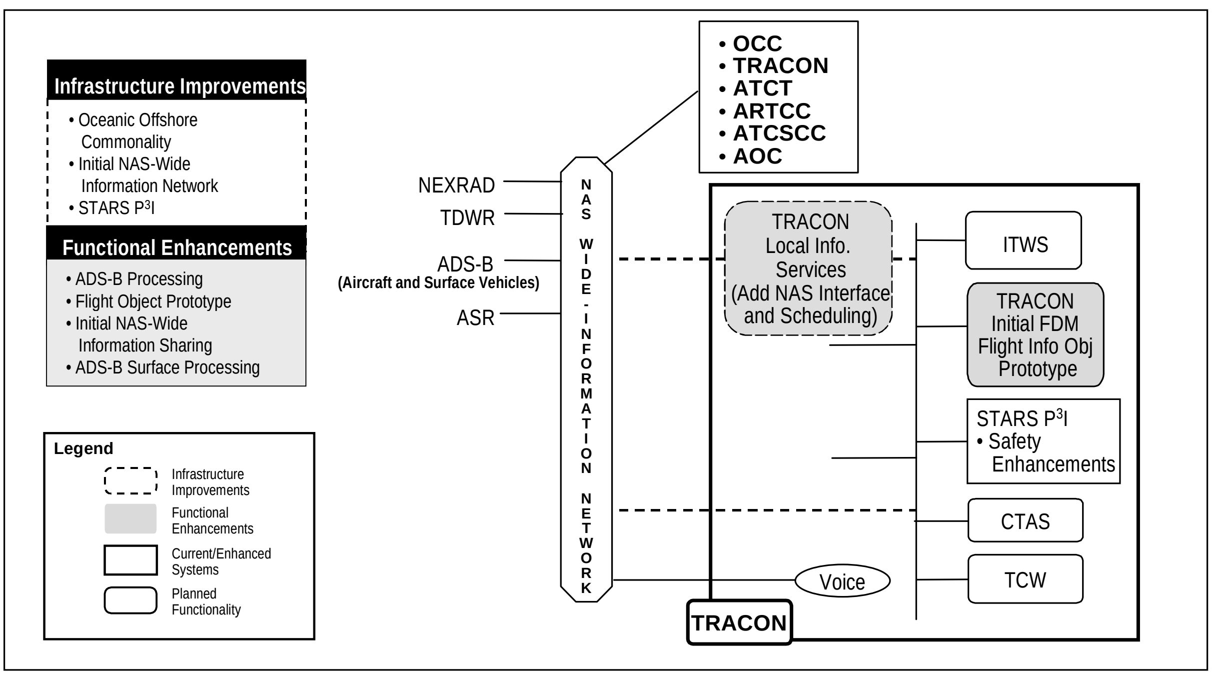

Figure 23-4. Terminal Architecture Evolution—Step 3 (2005–2007)

The integration of ADS-B data with data from surveillance sensors will require development of a multisensor fusion tracker. This ability to combine target reports from multiple sources to form a single track takes advantage of overlapping sensors and ADS-B data. This capability will improve the accuracy and availability of aircraft position data, potentially increasing the efficiency and safety of terminal operations and reducing reliance on any one sensor. Development of algorithms for terminal and en route data fusion will be done jointly, and fused surveillance data will be available for distribution to other TRACONs and ARTCCs via the NAS-wide information network.

PRM currently depends on a special electronically scanned radar to provide the rapid updates necessary to perform its monitoring function. Because of the update rates available with ADS-B, TRACON automation will be able to provide PRM functionality at many more facilities at a significantly lower implementation cost.

Safety Enhancements

Conflict alert, MCI, and MSAW are existing safety functions. The enhanced surveillance processing and tracking previously discussed will improve the probability of detection and reduce the false alarm rate associated with these functions. Merging approach and departure traffic will improve the effectiveness of conflict alert and runway incursion logic, and the display of both types of traffic on the same controller screen will improve situational awareness and safety. Incorporating intent data acquired through ADS-B will also improve conflict alert performance.

Flight Object Processor Prototype and Flight Data Management (FDM)

Currently, the ARTCC automation performs flight data processing for all aircraft within its assigned airspace, including aircraft under TRACON control. The limited set of prototype STARS FDP capabilities developed in Step 2 for the offshore facilities will be enhanced to provide FDM capabilities. This will be a coordinated effort with the en route FDM development and may become the model for the ultimate NAS-wide FDM. This FDM is an evolution from today's flight data processing capability that permits use of flight object data (defined in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing). This capability at TRACONs will eventually reduce terminal system dependence on ARTCC automation.

As local systems are replaced or new systems developed, commercial data base management systems will be used. This will enable data sharing (e.g., flight plan information, radar and weather data, maintenance information) between the various local terminal automation systems and applications (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

23.1.4 Terminal Architecture Evolution—Step 4 (2008–2015)

The logical terminal architecture is illustrated in Figure 23-5. The evolution of the terminal automation system toward a common hardware and software infrastructure for the offshore facilities will be accomplished in Step 4. Oceanic offshore automation system functionality will be fully integrated into the enhanced terminal offshore system. An FDM will be implemented to replace existing offshore and terminal FDP capabilities. The FDM expands on the FDP functionality and will use flight objects to disseminate flight status and traffic management information. The enhanced terminal and offshore system will provide an improved surveillance data processor for aircraft and surface vehicles. This automation system will allow more integrated surface and airspace operations, enabling the airport IFR capacity to more closely approach visual flight rule (VFR) capacity.

A common, modern platform infrastructure will provide for development of many advanced ATC decision support systems (DSSs). The controller, traffic flow managers, airline operation centers, pilots, and other NAS users will have access to the same DSS and information, which will enable a collaborative decisionmaking capability. The TRACON ATC DSS will integrate conformance monitoring, conflict resolution, and conflict probe capabilities as a coordinated set of controller tools. The reliance on paper flight strips will decline. pFAST capabilities will be upgraded to active FAST (aFAST) with greater precision in aircraft sequencing through recommended speed and

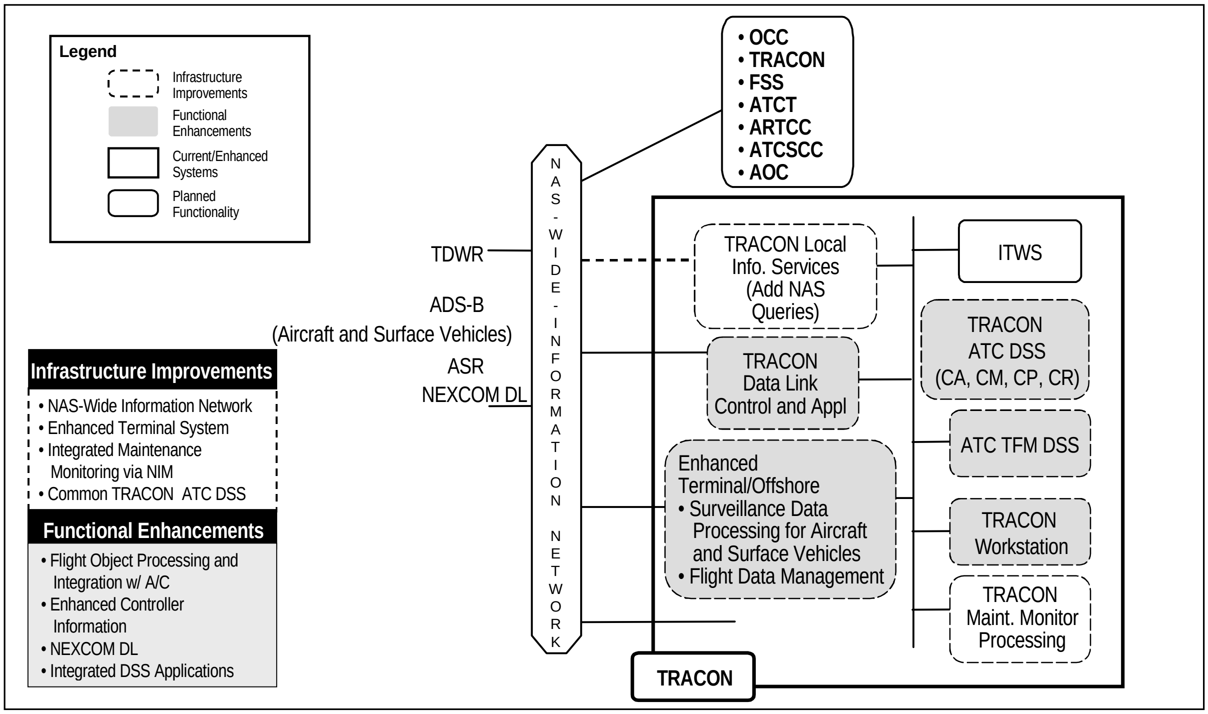

Figure 23-5. Terminal Architecture Evolution—Step 4 (2008–2015)

heading adjustments and aircraft wake vortex information in the spacing calculations to increase safety.

Data link capabilities will migrate from the service provider capability in the tower domain to the next-generation communication systems (e.g., NEXCOM). Full ATN-compliant controller-pilot data link communications (CPDLC) Build 3 service will support air-ground data exchange. The enhanced terminal automation system will use data link for communications and ADS-B to provide more accurate aircraft position reporting. This will allow more efficient use of terminal airspace and application of revised separation assurance standards. Eventually, with improved ground-based separation assurance and decision-making tools, used in conjunction with advanced cockpit display of surrounding traffic, pilots may be able to fly self-separation maneuvers during IFR conditions in the terminal area. This provides the capability to achieve VFR runway acceptance rates during IFR conditions.

An upgraded TDW that supports the integration of tower automation functions with terminal automation will be provided (see Section 24, Tower and Airport Surface).

The NAS-wide information network will conform to NAS-wide data standards, incorporate multi-level access control and data partitioning, provide data security, allow real-time data accessibility via queries, and assume all data routing and distribution functions, including data link. (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

23.2 Summary of Capabilities

Evolutionary refinements to terminal automation systems will result in DSSs that support flexible departure and arrival routes by using satellite-based navigation and improved communications and surveillance capabilities. Surveillance data processing will be performed in the terminal domain using a common processing system for both dependent surveillance data and radar/beacon data for ground and airborne traffic (see Figure 23-6).

The NAS-wide information network will provide exchange of real-time flight data among aircraft, ATC facilities, and AOCs, enabling a collaborative decisionmaking capability. Terminal automation improvements will also provide new interfaces for communications with external systems (e.g., CTAS/pFAST, PRM, SMA, AMASS, and

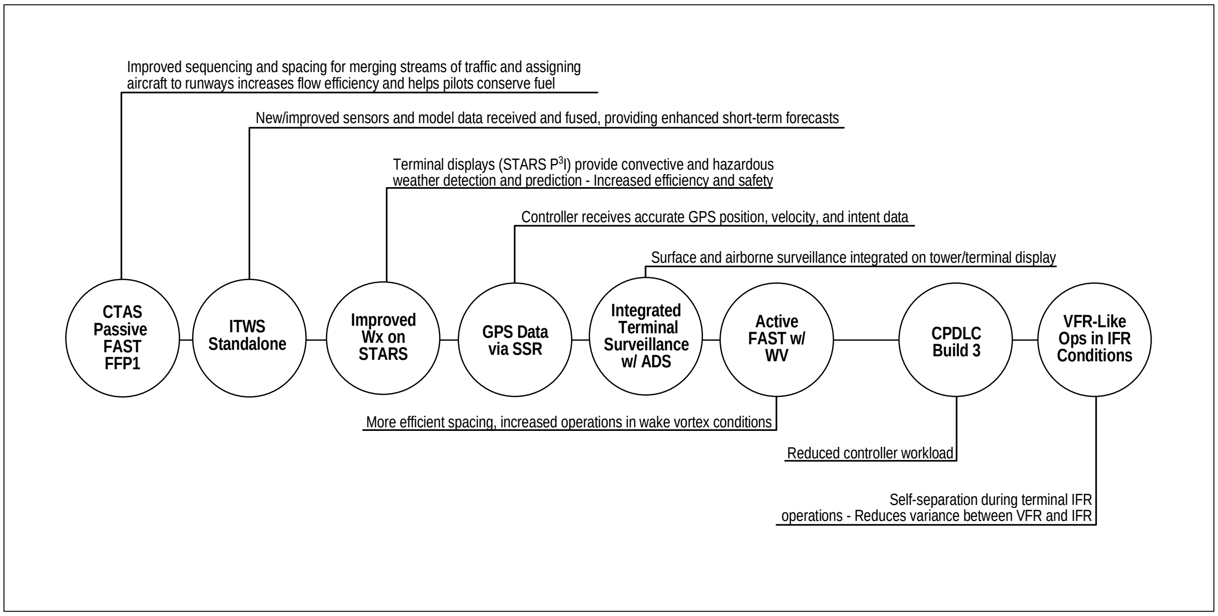

Figure 23-6. Terminal Architecture Evolution

ITWS). These new interfaces will add the capability to provide automation-generated data, such as tracks and flight plans to external systems, as well as a capability to receive and process data from external systems. In addition, the improvements will support surveillance system enhancements, improved weather display, data link, and conflict alert and Mode-C intruder alert enhancements.

The terminal automation suite will process surveillance data for surface vehicular traffic as well as aircraft for use in both the tower and terminal areas. The terminal automation suite will migrate to an enhanced terminal/offshore automation system that will evolve to a full set of TRACON ATC DSSs and TFM DSSs. The NAS-wide information network will improve collaborative decisionmaking between FAA and users.

The terminal automation system will use a digital data communications channel between terminal controllers and the aircraft in terminal airspace. This channel will supplement the controller's existing voice channel, and will allow the controller to move many of the regular and routine functions from the voice (very high frequency (VHF)) radio communications to a second, parallel communications channel. Studies have shown that this terminal data link application, computer-human interface (CHI), and second data communications channel will help terminal controllers to communicate with pilots more effectively, manage terminal airspace more efficiently, and to potentially enable significant user cost savings.

23.3 Human Factors

New hardware and software tools will improve the way controllers conduct terminal operations and provide traffic management services. Human factors efforts will focus on enhancing controller performance through:

- Upgrading the human interface with communications, new surveillance sources, and DSSs
- Using results from simulations and cognitive modeling for decision support tools to facilitate aircraft, ATC, and airline operations real-time flight data sharing
- Enhancing procedures for using surface, airline operations, and traffic-flow information for collaborative decisions involving arrival and departure sequencing
- Improving displays of new information involving airport surface movement, aircraft tracks, flight plans, and weather
- Changing training concepts to support such tools and new technologies as data link.

23.4 Transition

The terminal domain transition schedule is shown in Figure 23-7. These capabilities will be deployed during the transition:

- STARS deployment
- STARS P3I
  - – CTAS/pFAST, PRM, AMASS, SMA interfaces, Free-Form text, and ASTERIX
  - – PRM internal to STARS
  - – CTAS/a FAST
- Surface ADS-B, terminal-offshore integration
- Data link via NEXCOM
- SDP, SDP-to-off-shore
- Initiate STARS Hardware Upgrade 1 (Repeat at 6-year intervals)
- Enhanced terminal functionality
- Terminal-tower integration.

23.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for the terminal architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 23-8.

23.6 Watch Items

Achieving terminal functionality and operational benefits within the schedules and budgets described in the architecture depends on the funding and success of the following funding activities:

- Timely deployment of STARS to solve the infrastructure replacement problems in the near term and provide a bridge to the new capabilities of the reengineered terminal system
- Demonstrate, as a part of Safe Flight 21, the ability of ground automation systems to process improved surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS, to merge these data with radar data, and to display this information to controllers with an acceptable CHI. Results of these demonstrations would include processing algorithms and CHI standards that could then be incorporated into the terminal core functionality between 2005 and 2008.
- Success of the FFP1 CCLD prototypes for the terminal domain (CTAS/pFAST).

The budget for incorporating some of the future functionality is related to developing common al-

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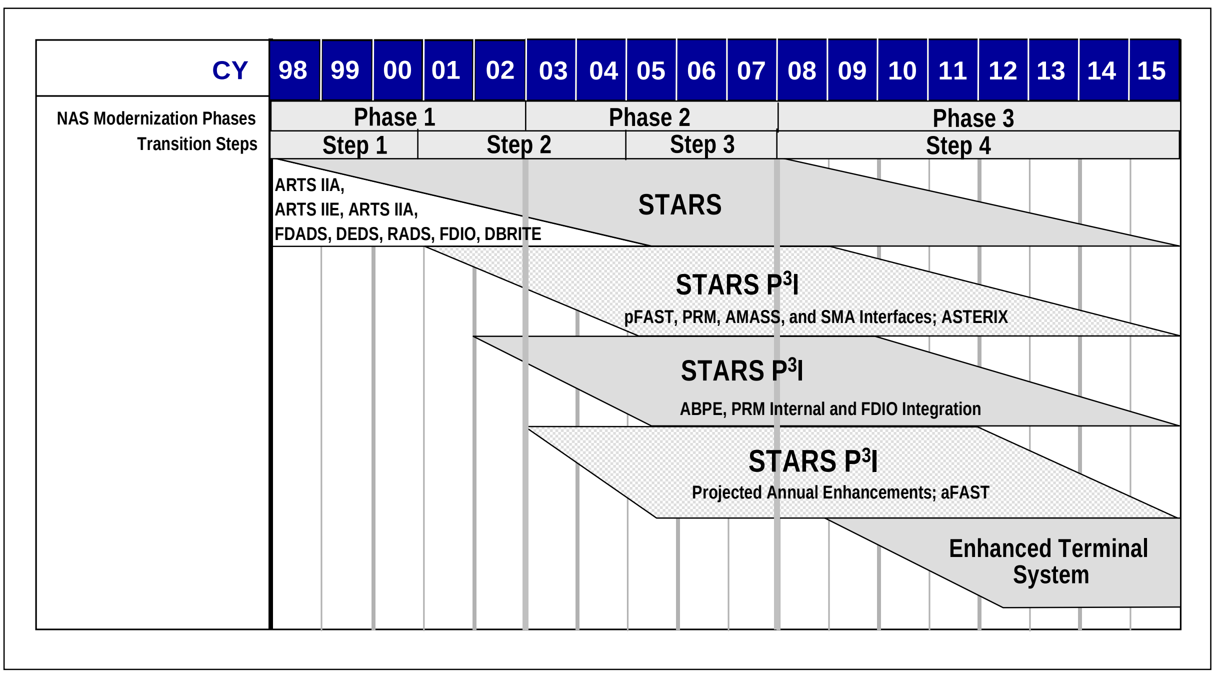

Figure 23-7. Terminal Automation Transition

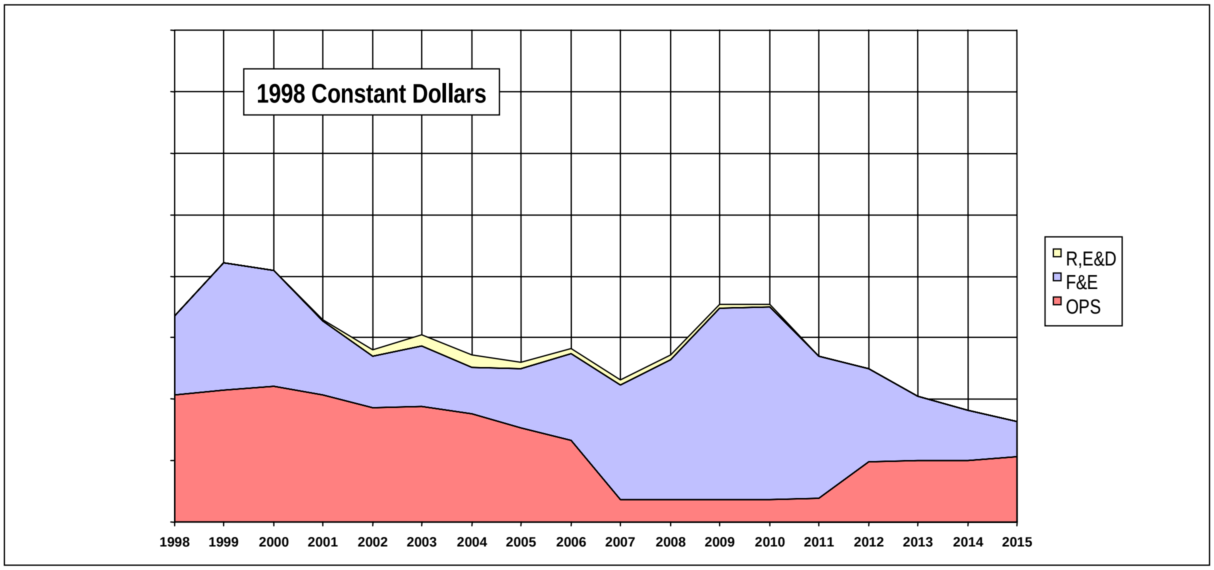

Figure 23-8. Estimated Terminal Automation Costs

gorithms to provide this functionality across domains where appropriate. Areas where common functionality across domains is anticipated are:

- Common surveillance processing and ADS/ radar data fusion in the terminal, en route, and surface domains
- Common weather services
- Common flight object processing
- Common functionality in some ATC DSSs and safety-related tools.

It is understood that this development process will increase dependencies between domains, but it is also understood that current budgets do not allow separate development in each domain. Therefore, it is essential that many of these efforts begin in the near-term to reduce long-term production risks.

24 TOWER AND AIRPORT SURFACE

Operated by the FAA, the Department of Defense (DOD), contractors to the FAA, and nonfederal organizations, airport traffic control tower (ATCT) facilities are primarily responsible for ensuring sufficient runway separation between landing and departing aircraft. ATCTs also relay instrument flight rules (IFR) clearances, provide taxi instructions, and assist airborne aircraft within the immediate vicinity of the airport.

The concept of operations (CONOPS) calls for integrating arrival and departure services with airport surface operations. Future tower and airport surface capabilities include:

- Improved information exchange and coordination activities, including expansion of data link capabilities to more users at more airports
- Automation to enhance the dynamic planning of surface movement, balancing runway demand, and improving the sequencing of aircraft to the departure threshold
- Automation to improve the identification and predicted movement of all vehicles on the airport movement area, including conflict advisories
- Safety and efficiency enhancements by planning an aircraft's movement such that a flight can go directly from deicing to takeoff without risk of requiring another deicing cycle due to taxi delays
- Integration of surface automation with departure and arrival automation so that the arrival runway and taxi route are optimally assigned with respect to the gate assignment (Current and projected areas of congestion on the surface, runway loading, and environmental constraints will also be taken into consideration.)
- Increased collaboration and information sharing among users, service providers, and airport management to create a more complete picture of airport demand.

The goal in the tower/airport surface domain is to improve the exchange of information not only between service providers and actively controlled aircraft but also among all users located at the airport. This exchange will enhance operational efficiency and safety of aircraft movement on the airport surface.

This section describes the capabilities and associated systems that are envisioned as part of the architecture for the tower/airport surface domain. It focuses on the evolution of automation in ATCTs. The evolution and expansion of data link services in the airport environment was described in Section 17, Communications. The airport architecture is discussed in Section 28, Airports.

Figure 24-1 depicts the future ATCT architecture for high-activity towers, which includes the following components:

- Controller workstation networks
- Dedicated ATCT local area networks (LANs) for transferring data and information between facilities
- Enhanced next-generation information display systems (E-IDSs)[1] for consolidating status and control devices in the tower cab
- Upgraded tower display workstations (TDWs) for integrating tactical and strategic decision support applications and facilitating the addition of newer capabilities into tower cabs
- LANs in terminal radar approach control (TRACON) and air route traffic control center (ARTCC) facilities will communicate via aeronautical telecommunications network (ATN)-compatible routers over a wide area network (WAN) with an ATCT LAN.

Low- and moderate-activity towers will have less functionality and a limited number of display types.

ATCT Architecture

Controller Workstations. The long-term goal of the tower architecture is to create a modular workstation with three displays to present alphanumeric data, radar and weather information, and

1. E-IDS will be developed from the current Systems Atlanta Information Display System (SAIDS) and ASOS controller equipment (ACE) functionalities.

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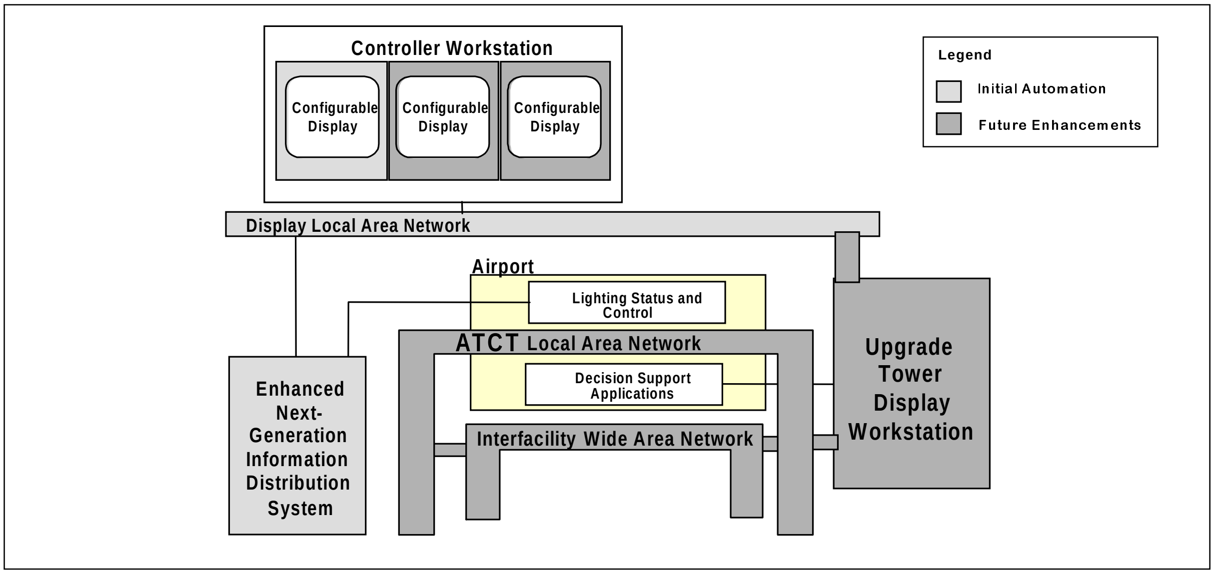

Figure 24-1. Future Airport Traffic Control Tower Functional Architecture

communications access and control information. This basic workstation can be configured to the specific needs of each type of controller position. Many positions in the tower cab do not require three displays. Wherever possible, controller workstations will be configured to reduce the number of displays. The clearance delivery position, for example, might use a single display for predeparture clearance (PDC) delivery information and for communications access and control. The local controller will likely have one display for airborne traffic, another for surface traffic, and a third display presenting consolidated status and control information. Some displays may incorporate touch-screen and/or voice recognition capabilities to reduce the amount of heads-down time spent on keyboard and trackball data entry.

Automation Enhancements. Data and information will be processed to provide new services and improve existing services displayed on the tower color display, which is suitable for high ambient light conditions. New applications will include integrating and rehosting existing functions onto controller displays.

NAS users outside the tower (such as airport managers, airline dispatchers, and ramp controllers) who need access to NAS information will connect with the tower LAN and, where appropriate, over the interfacility WAN. Access to the WAN will be restricted by suitable data security and integrity precautions.

24.1 Airport Traffic Control Tower Architecture Evolution

The ATCT architecture includes the overlapping steps shown in Figure 24-2. Step 1 maintains all currently installed tower systems, including the major ones purchased by regional or airport authorities. The three subsequent steps will replace various devices in the tower cab with new automation, integrating functions in the tower cab and interfacing with the NAS-wide information network, described in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing.

The first improvement deploys the Airport Movement Area Safety System (AMASS) and the initial surface movement advisor (SMA) to high-activity airports. AMASS detects and alerts tower controllers of actual and potential runway incursions. Initial SMA, as defined for the Free Flight Phase 1 Core Capability Limited Deployment (FFP1 CCLD) (see Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone), provides a one-way feed of aircraft arrival, departure, and status information to ramp control operators.

The existing digital bright radar indicator tower equipment (DBRITE) displays will be replaced by the TDW displays procured under the Standard Terminal Automation Replacement System (STARS) program (see Section 23, Terminal). About the same time, data link delivery of taxi clearances (DDTC) (the prototype currently being

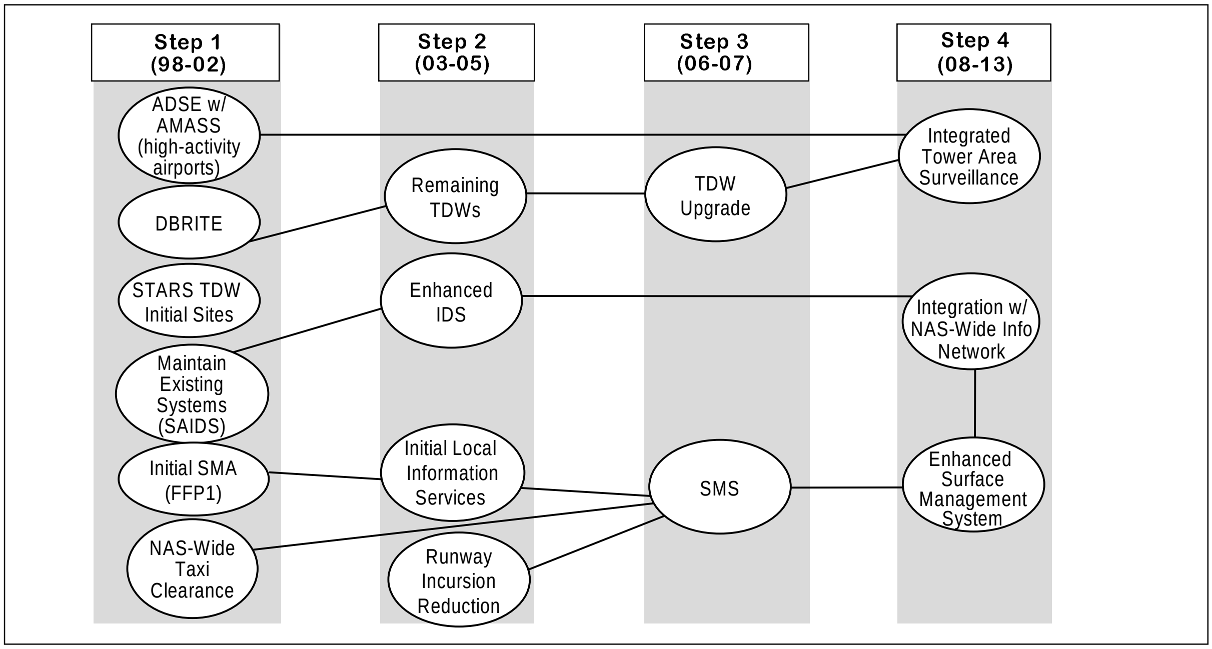

Figure 24-2. Airport Traffic Control Tower Architecture Evolution

evaluated in Detroit) is anticipated to be deployed nationally to provide new capabilities to the ATCT domain. E-IDS will be deployed to consolidate status and control devices in the tower cab.

A fully operational surface management system (SMS), which evolved from the Atlanta airport prototype of the SMA, will be installed at high-activity airports. An upgraded TDW will be implemented in high-activity towers, which will enable controllers in those towers to monitor both surface and airborne traffic via an integrated surveillance display, configurable to the particular needs of the control position in the tower. (Some positions may still use two situation displays—one configured for surface and another configured for airborne.) Subsequent sections describe these transition steps in more detail.

The following paragraphs present the tower and airport surface architecture evolution in more detail. The architecture diagrams show the content of each step in a logical or functional representation without any intention of implying a physical design or solution.

24.1.1 Airport Traffic Control Tower Architecture Evolution—Step 1 (Current–2002)

Figure 24-3 illustrates the first step in the evolution from the current ATCT architecture to the future ATCT architecture. This step establishes a nationally managed maintenance program to improve configuration management and the coordination and maintenance of the many nonstandard tower systems, including those purchased by regional or airport authorities.

The immediate problem addressed in this step is establishing a NAS-level maintenance program for the Systems Atlanta Information Display System (SAIDS). SAIDS is a proprietary display system that provides tower controllers the capability to receive and disseminate locally determined airport information, including weather and airport advisories. It is installed in more than 200 ATCTs and 25 associated TRACON facilities. SAIDS is also installed in more than 300 other facilities—including some ARTCCs, regional FAA offices, flight service stations, military air bases, and non-government facilities.

These systems were not installed under a national program, and all maintenance is performed through commercial contracts. A mission analysis is currently underway to investigate the upgrade of SAIDS to NAS standards, establish configuration control over the system, recognize it as an official FAA program, and integrate it into the FAA's overall NAS maintenance program.

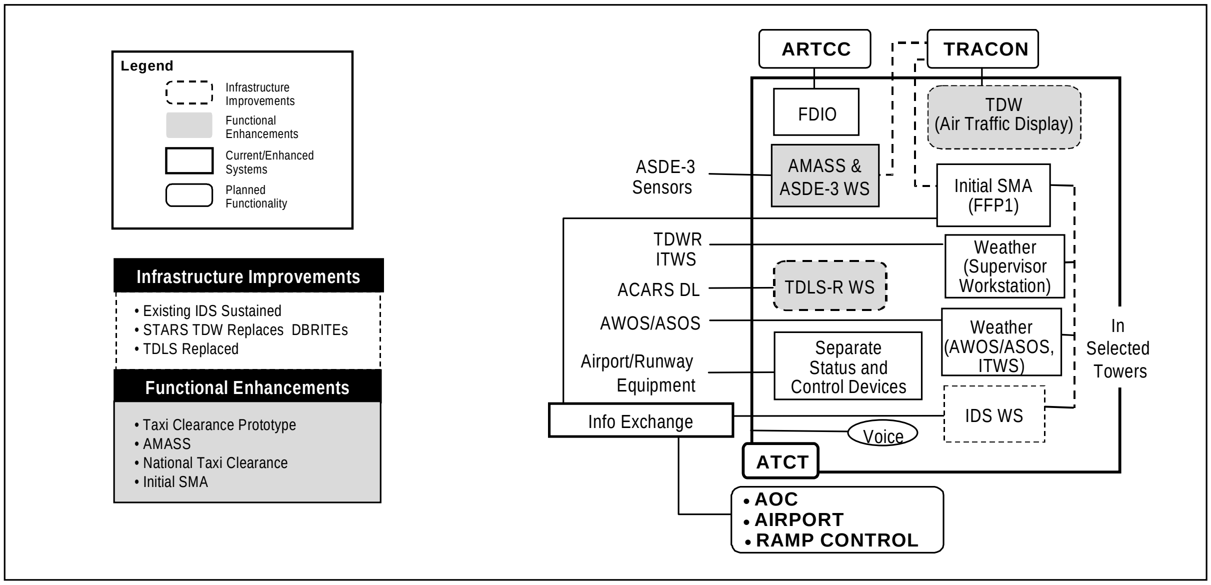

Figure 24-3. Airport Traffic Control Tower Architecture Evolution—Step 1 (Current–2002)

AMASS provides alert information to controllers of potential conflicts between arriving aircraft and surface traffic or between aircraft and vehicles on the surface via audible cautions and warning and visual information superimposed on the airport surface detection equipment (ASDE-3) display in ATCTs.

AMASS is scheduled for deployment to 34 high-activity airports. Prototypes are currently installed at Detroit and St. Louis. AMASS requires a one-way interface to receive data from the terminal automation system. AMASS processes surveillance data from the terminal automation system (automated radar terminal system (ARTS) and/or STARS), ASDE-3, and the airport surveillance radar-model 9 (ASR-9) to define the position, direction, and velocity of all airport targets.

A redefined initial SMA will be implemented as part of FFP1 CCLD to achieve early benefits to ATC and NAS users by providing a form of limited collaborative decisionmaking capability. Specifically, initial SMA for FFP1 CCLD will provide aircraft arrival information through the terminal automation system (ARTS and/or STARS) to airline ramp control operators.

During this step, TDW displays procured under the STARS program will begin to replace DBRITE displays.

Data from all local weather sensors/processors (terminal Doppler weather radar (TDWR), low-level windshear alert system (LLWAS), runway visual range (RVR), automated surface observing system (ASOS), and the airport surveillance radar–model 9 (ASR-9) weather channel) will begin to be available from the TRACON-installed integrated terminal weather system (ITWS) at 45 high-activity airports. From these sources, ITWS will provide both tower and terminal service providers with a set of airport weather products, including warnings of the most severe forms of windshear, turbulence, thunderstorm, heavy snow, and aircraft icing potential hazards (see the discussion on weather systems in Section 26, Aviation Weather).

Transmission of taxi clearances via data link (the DDTC prototype is currently being evaluated in Detroit) is expected to be deployed nationally. During this transition period, PDCs and digital automatic terminal information services (D-ATIS) will continue to be provided over the aircraft communications addressing and reporting system (ACARS) via ARINC.

PDC assists the tower clearance delivery specialist in composing and delivering departure clearances. The automatic terminal information service (ATIS) equipment enables controllers to formulate ATIS text messages for delivery. The ATIS text messages are then delivered to flight crews

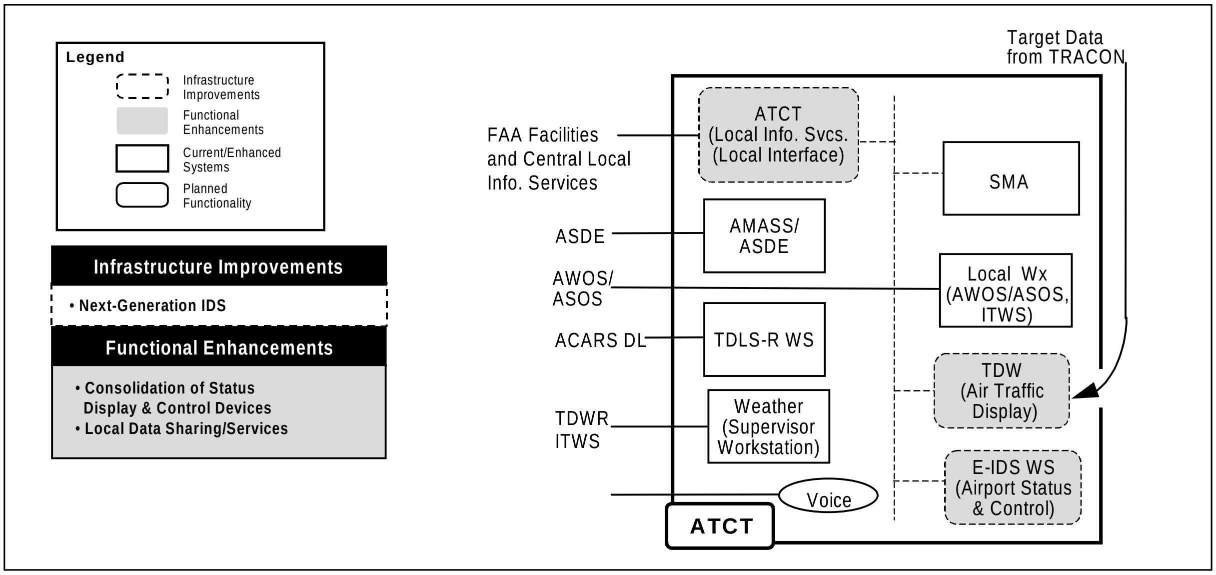

Figure 24-4. Airport Traffic Control Tower Architecture Evolution—Step 2 (2003–2005)

via ACARS data link. An ATIS automatic voice generation function produces spoken broadcasts using a synthesized voice to read the ATIS message.

24.1.2 Airport Traffic Control Tower Architecture Evolution—Step 2 (2003–2005)

Figure 24-4 depicts the transition during Step 2. The TDW will have replaced most remaining DBRITEs.

E-IDS will be implemented to reduce the number of displays and data entry devices. E-IDS uses an open system architecture to integrate the functionality of SAIDS and ASOS controller equipment (ACE), centralize the status indicators and control of airport lighting systems, eliminate multiple manual panels scattered throughout the tower cab. E-IDS will increase the timeliness and quality of weather, traffic, and system status data for service providers as well as the quality of services for users.

Based on lessons learned from initial SMA, users and service providers will determine whether national deployment is beneficial.

New runway incursion reduction capabilities will be implemented to help reduce the possibility of traffic conflicts; this includes additional surveillance, ATC tools, signage, lighting, new procedures, and increased training. The installation of a new surface surveillance/conflict detection system for additional airports that do not have ADSE/AMASS is expected to begin.

The first increment of local data-sharing services will enable all intrafacility systems to share common data.

24.1.3 Airport Traffic Control Tower Architecture Evolution—Step 3 (2006–2007)

This step begins the enhancement of the local information services in preparing for the NAS-wide information network, upgrades the TDWs, and initiates a next-generation SMA called a surface management system (SMS) (see Figure 24-5).

As local legacy systems are replaced or new systems developed, commercial data base management systems will be used where applicable and models of information for all systems will be based on managed data standards. The NAS-wide information network will evolve from local information data exchange to interfacility information exchange. Structured data will be accessible by external applications. The NAS information network will provide information to both users and controllers, taking into account necessary security policies and precautions.

High-activity towers will begin to receive an upgraded TDW that will accommodate selected additional data entry and display. The TDW will be used to display a mixture of terminal and surface information (see Section 23, Terminal). Tower controllers will be able to monitor both surface

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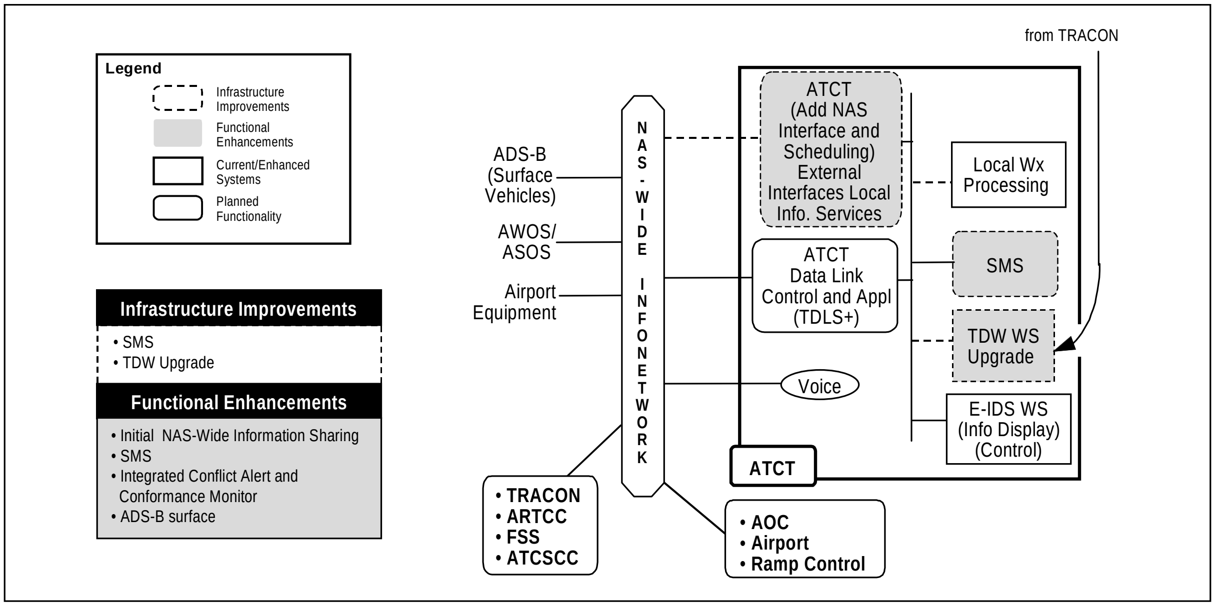

Figure 24-5. Airport Traffic Control Tower Architecture Evolution—Step 3 (2006–2007)

and airborne traffic via integrated surveillance displays, configurable to the particular needs of the control position in the tower. Surface traffic will be displayed with a perimeter "look-ahead" for airborne traffic. Airborne traffic may be displayed with an inset for runway and adjacent taxiway activity.

A next-generation SMS will be deployed at selected high-activity airports. The exact features of SMS have yet to be defined, but it will include enhanced decision support to aid movement sequencing and scheduling in conjunction with TRACON operations.

The tower data link services (TDLS) will automate tower-generated information for transmission to aircraft via data link. The TDLS interfaces with sources of local weather data and flight data and provides PDCs and D-ATIS.

24.1.4 Airport Traffic Control Tower Architecture Evolution—Step 4 (2008–2015)

Early in this step, airports will have access to the NAS-wide information network to provide complete data connectivity among service providers, airline operation centers (AOCs), airport operators, and airport emergency centers (see Figure 24-6).

In the far term, ATCT surveillance will be provided by the all-digital system that was developed from the terminal surveillance data processor (SDP), which was described in Section 23, Terminal. Surveillance data from all sensors and systems covering airborne and surface vehicles will be fused, creating a track file for use by all automation functions. This front-end surveillance processor function will produce a synergetic surveillance data base, permitting automation functions that use "best quality" surveillance data for specific purposes.

The introduction of the Local Area Augmentation System (LAAS) for the Global Positioning System (GPS) and automatic dependent surveillance (ADS) data will greatly increase the accuracy of position data from both surface vehicles and aircraft traffic

The enhanced SMS will be fully integrated into the automation platform provided by the TDW upgrade for surface planning and monitoring. The SMS will contain information on environmental and operational conditions at the airport and send updates to the NAS-wide information network. The SMS and NAS-wide information network inform service providers of all arrival, surface, and departure schedules. The systems also interface with surface and airborne surveillance information, flight information, weather, and traffic management systems. This data sharing at the airport allows service providers to coordinate local operations with airline ramp and airport operators, improving airport operations. SMS will integrate

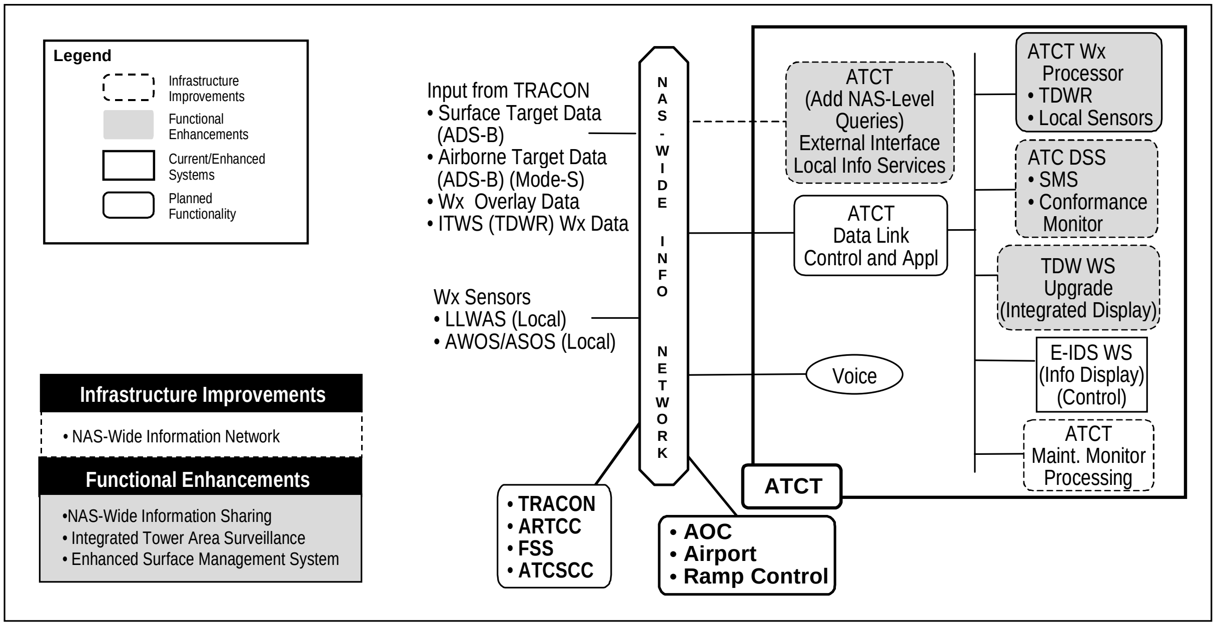

Figure 24-6. Airport Traffic Control Tower Architecture Evolution—Step 4 (2008–2015)

planning functions, providing an expanded conformance monitoring and probe function that could data-link an alert directly to the cockpit.

All these automation systems will support monitoring, routing, and timing of aircraft surface movement and will be fully integrated with the flight data, traffic management, and local weather system functions. Surface map displays of automated surface movement safety and guidance information will be available in both the tower and cockpit to enhance coordination.

Flight data processing will be integrated with real-time tower operations. Conflict detection will be available for integrated terminal and surface operations; the information will be displayed in towers and TRACONs. Finally, improved metering, sequencing, and spacing aids will be used for arrivals and departures, which will increase airport capacity and improve surface operations.

Data link services in the tower/airport domain will evolve from services developed for the en route and terminal domains. Thus, until this step, data link services continue to involve only the uplink of information to aircraft and require no reply from the flight deck.

As data link evolves, the capability for controller-pilot dialogue to communicate strategic and tactical air traffic service messages that are currently conveyed by voice will be implemented and may be transitioned to the tower domain depending on their success. A ground-based processor will receive a downlinked request from the flight deck, compile the requested information, and uplink it to the aircraft for display. Next, data link will facilitate the downlink of weather and aircraft state-and-intent information to improve the prediction capabilities of decision support and weather systems.

24.2 Summary of Capabilities

The summary of the tower/airport traffic handling capabilities is depicted in Figure 24-7. These capabilities will be enhanced by removing constraints to aircraft movement, from gate pushback to the runway and from landing rollout to the gate. Airport surface movement operations and information exchange coordination will be facilitated by the expanded use of data link capabilities and the incorporation of cockpit avionics (e.g., GPS/automatic dependent surveillance broadcast (ADS-B)) to display airport surface position and other traffic. This will provide cockpit crews with improved situational awareness and conflict advisories so that they can conduct all-weather, low-visibility taxi operations. The NAS will also feature enhanced decision support tools designed to improve planning of airport surface movement, balancing runway arrival/departure demand, and

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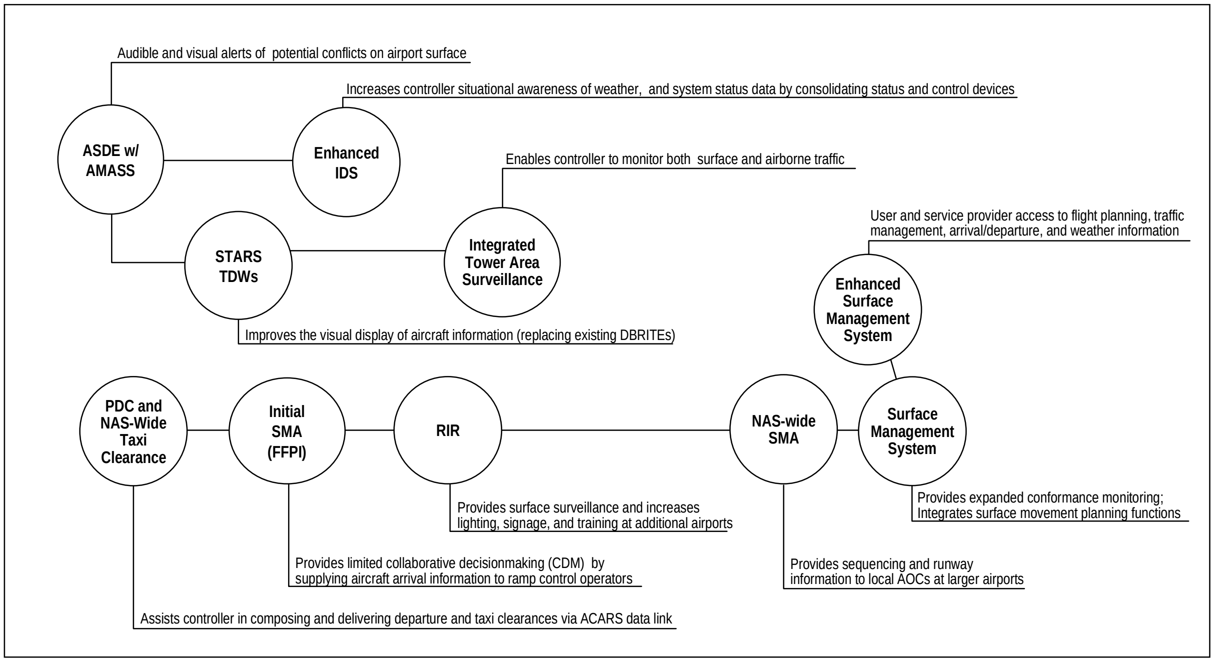

Figure 24-7. Tower and Airport Surface Capabilities Summary

sequencing of aircraft by performance type to the departure runway.

The integration of tower/surface automation with the terminal arrival/departure automation systems will also help relieve congestion at the runway threshold by integrating runway demand with operational capability to handle the airborne and surface traffic load.

24.3 Human Factors

Human factors efforts in developing prototypes, conducting simulations, assessing human-system performance against baselines, integrating workstations, and training for new systems include:

- Designing new automation interfaces for tower controller traffic management tasks, such as monitoring, routing, and timing surface movement
- Establishing methods and procedures for new enabling technologies, such as voice recognition and synthetic voice, to reduce controller head-down time and facilitate routine repetitive tasks
- Designing the human interface for integrated displays of information related to weather, surface movement, arrival and departure management, and system status
- Integrating automated operations related to flight data processing, tactical conflict detection, and improved spacing and sequencing
- Increasing efficiency of controller tasks, such as departure clearance services, flight plan data access, and landing and taxi control operations
- Allocating roles and responsibilities for collaborative controller planning and decision-making under various system constraints and alternatives.

24.4 Transition

Figure 24-8 depicts the transition to the ATCT architecture. For a significant period, the current ATCT systems will be sustained. The E-IDS will be deployed to consolidate status and display devices in the tower cab. All high-activity towers will be equipped with IDS, followed by installation of IDS in moderate-activity towers. The high-activity towers will receive the upgraded TDW, which will integrate the platform for the majority of applications in ATCTs.

24.5 Costs

The FAA estimated costs for facilities and equipment (F&E), operations (OPS), and research, engineering, and development (R,E&D) for the

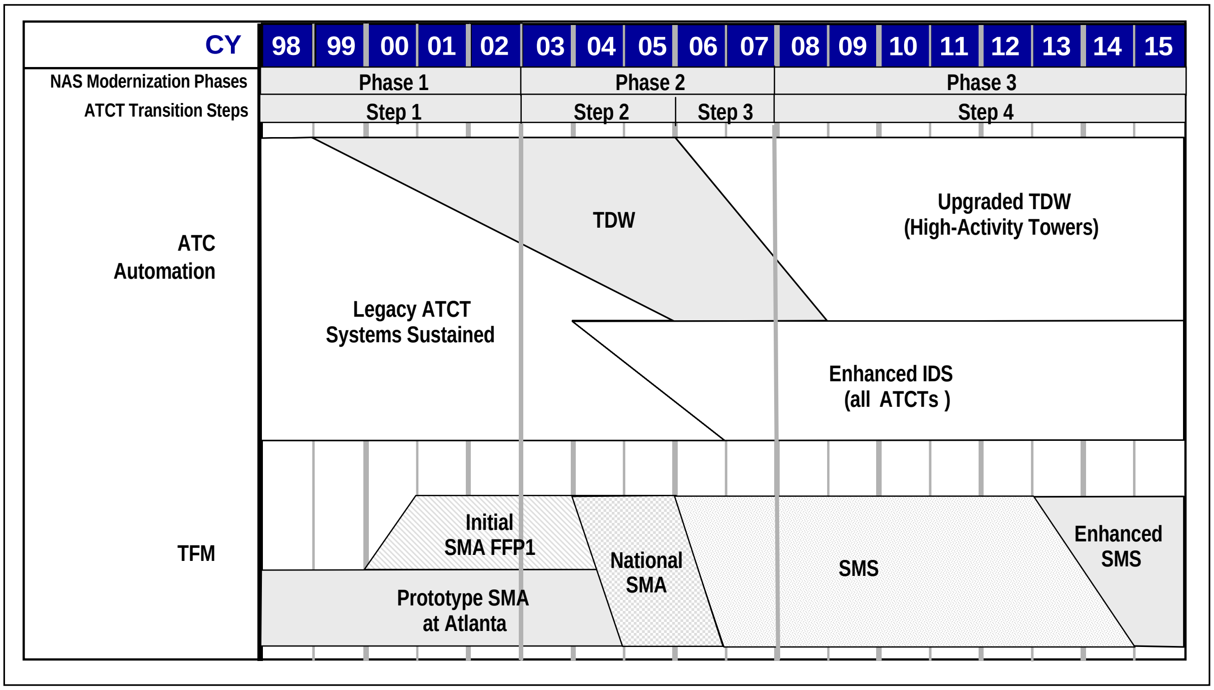

Figure 24-8. Airport Traffic Control Tower Architecture Transition

tower automation architecture from 1998 through 2015 are presented in constant FY98 dollars in-Figure 24-9. This excludes costs associated with DBRITE replacement in the STARS program (see Section 23, Terminal), LAAS landing systems (see Section 15, Navigation, Landing, and Lighting Systems), or weather systems (see Section 26, Aviation Weather).

24.6 Watch Items

A Tower and Airport Surface program (e.g., automation, information display system (IDS), TDWs) is needed. The ATCT enhancements are highly dependent on developments in other domains. The FAA recognized the need to assess its ability to implement and integrate the DSSs on the tower displays, and that there is yet to be any

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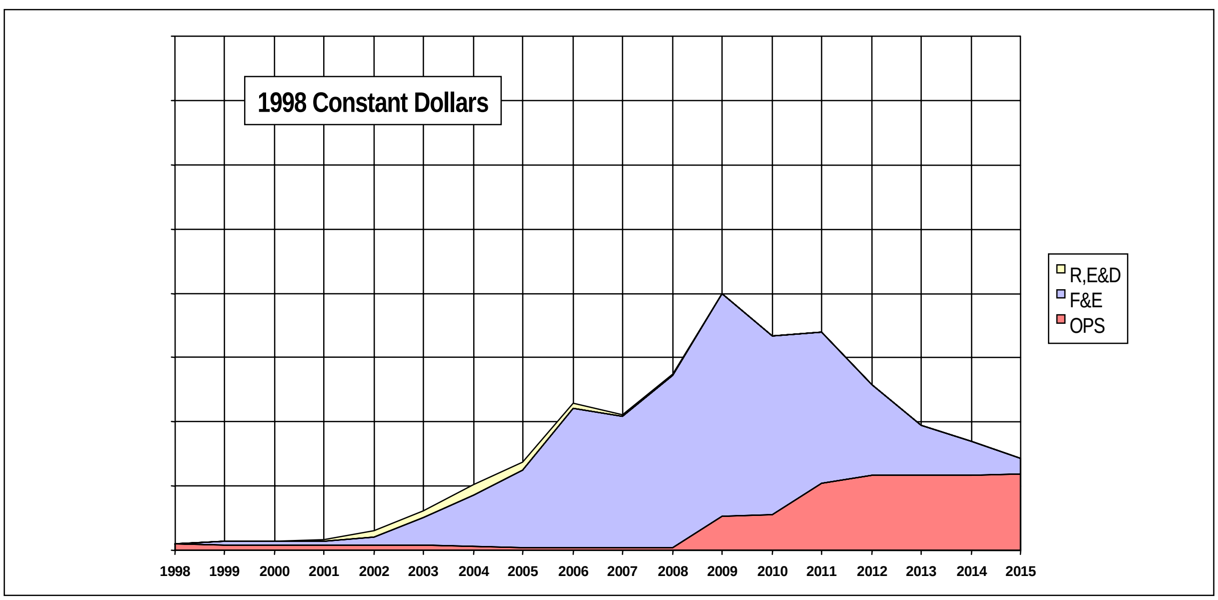

Figure 24-9. Estimated Airport Traffic Control Tower Automation Architecture Costs

commitment made to implementing these capabilities. Surface movement guidance and control require significant integration to provide the needed services without distracting from the need to keep most of a controller's workload focused on visually observing traffic.

25 FLIGHT SERVICES

FAA flight service stations (FSSs) provide accurate and timely aviation weather, aeronautical information, and flight planning assistance to commercial, general aviation (GA), and occasionally military pilots. Most military flight plans are entered into the NAS by military base operations (MBO) interfaces with FSSs. Disseminating this information is critical to safe and efficient operation of the NAS. Functional enhancements include the following capabilities:

- Increase pilots' ability to access information via automation sources, both prior to flight and while airborne
- Enhance the ability of FSS specialists to utilize current information (i.e., notices to airmen (NOTAMs) and hazardous weather advisories) when briefing or assisting pilots
- Modernize communications while retaining in-flight voice services and associated infrastructure as a governmental function
- Provide access to a NAS-wide information network for obtaining and distributing flight-specific data and aeronautical information
- Provide interactive aids that improve the user's ability to execute flight plans, thereby facilitating a more collaborative role for users in obtaining NAS information, such as special use airspace (SUA) status, and traffic density
- Standardize domestic and international flight and weather information.

In the future, the responsibility for NAS flight services will be shared between the government and the private sector. Efforts are currently underway to further define the services provided by FSS specialists and the private sector.

25.1 Flight Services Architecture Evolution

Today, pilots can obtain services directly from an FSS via telephone or by using personal computers to obtain weather and preplanning services from commercial or FAA systems. A number of states and localities provide this arrangement via self-service kiosks, which provide remote, automated access to everyone, as well as convenient on-airport access by pilots. Commercial enterprises will continue to be active in providing preflight services (for a fee) in the near term. As pilots become more self-reliant, the number of specialist-provided, preflight transactions (briefings and flight plan filings) will decline. The rate of decline cannot be predicted, but GA use of direct user access terminal (DUAT) service has grown steadily. In addition, the trend for states to contract with commercial vendors to supplement FSS-provided services is likely to continue.

25.1.1 Flight Services Architecture Evolution—Step 1 (1998)

Currently, flight services are provided to pilots via any one of the 61 automated flight service station (AFSS) facilities or remotely via the DUAT service in the continental United States. Additionally, 14 manual FSS facilities are located in Alaska.

The flight service automation system (FSAS) Model 1 Full Capacity (M1FC) system was deployed in the late 1980s. The FSAS consists of:

- Two aviation weather processors (AWPs) that supply a uniform set of global flight planning and alphanumeric weather data
- Approximately 1,500 flight service position consoles used by FSS specialists
- User access to weather briefings and flight plan processing via DUAT service.

As the original FSAS system offered limited capabilities, it was later augmented with a graphic weather display system (GWDS) and the DUAT service to supplement pilot access to the information available in the FAA automation systems.

Current preflight and in-flight service functions include:

- Filing instrument flight rules (IFR), visual flight rules (VFR), and defense (military) visual flight rules (DVFR) flight plans
- Providing VFR flight following, and initiating and coordinating search and rescue (SAR) activities
- Providing broadcast messages
- Providing user access to weather briefings and flight plan processing via DUAT service

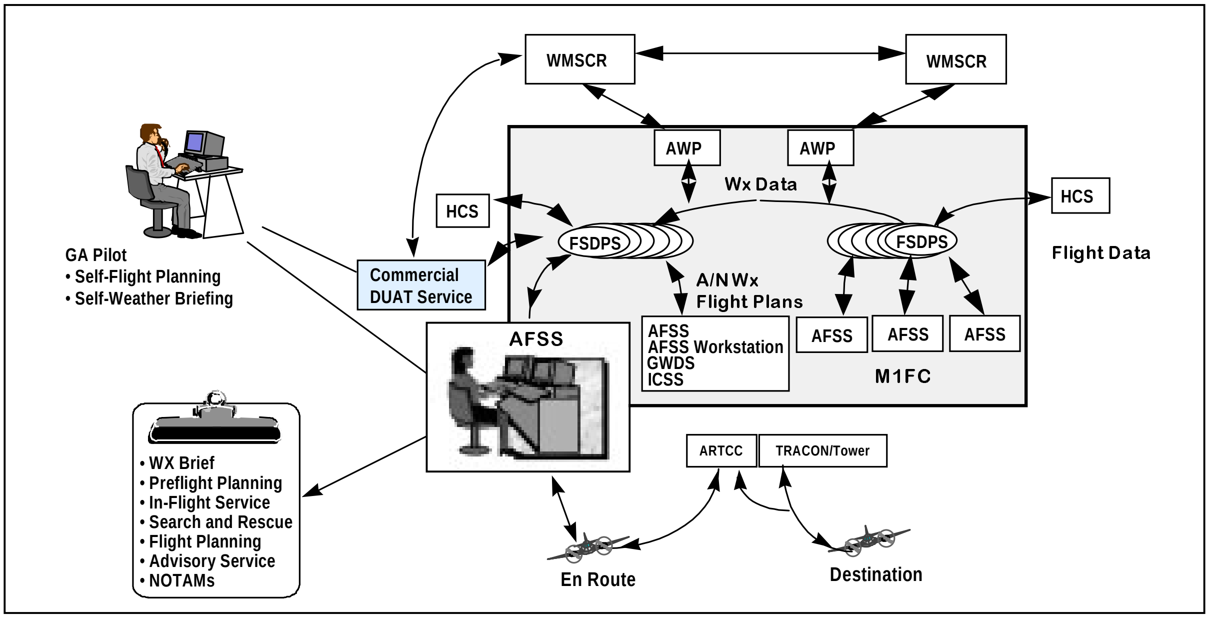

Figure 25-1. Flight Services Architecture—Step 1 (1998)

- Disseminating NOTAMs
- Processing and disseminating pilot reports (PIREPs)
- Providing emergency services
- Providing other services as requested.

Figure 25-1 depicts the current flight services architecture. The ensuing architecture discussion addresses changes within the FSAS structure.

25.1.2 Flight Services Architecture Evolution—Step 2 (1999–2005)

Almost immediately in Step 2, the Operational and Supportability Implementation System (OASIS), a new commercial-off-the-shelf (COTS)-based capabilities system, will replace the existing AFSS automation (i.e., FSAS). OASIS will allow pilots to self-brief and to file flight plans directly. For those pilots unable to self-brief or who require direct contact, flight service specialists will be available. OASIS will be provided as a leased service and includes a reliable, open systems compliant hardware and software system configuration. Figure 25-2 illustrates the near-term, Step 2 architecture for flight services.

OASIS contains significant computer-human interface (CHI) improvements that provide standardized products to both the specialist and the pilot. The existing FSAS display will be replaced with a graphical user interface, enabling automated information retrieval while enhancing processing and storage performance. Initially, OASIS provides greater coordination and checking of flight plans with the Host/oceanic computer system replacement (HOCSR).

The FAA is undertaking an initiative called Safe Flight 21 to demonstrate and validate an integrated set of capabilities leading to Free Flight. An overview of Safe Flight 21 is provided in Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone. Flight information services (FIS) transmits noncontrol information such as weather data, NOTAMs, and SUA information. Safe Flight 21 demonstration validations (DEMVALs) for FIS and weather services will involve specific operational improvements for different aircraft types operating at various altitudes under IFR and VFR flight plans. The DEMVALs will also include the impact of FIS/weather data link on air traffic control procedures, pilot-controller responsibility for severe weather separation, and collaborative decisionmaking. Weather support to Safe Flight 21 will be provided by the weather and radar processor (WARP) and OASIS and tailored in accordance with each DEMVAL.

As pilots become more self-reliant and depend less on direct contact, in-flight services (e.g., in-flight weather support, VFR flight following, and

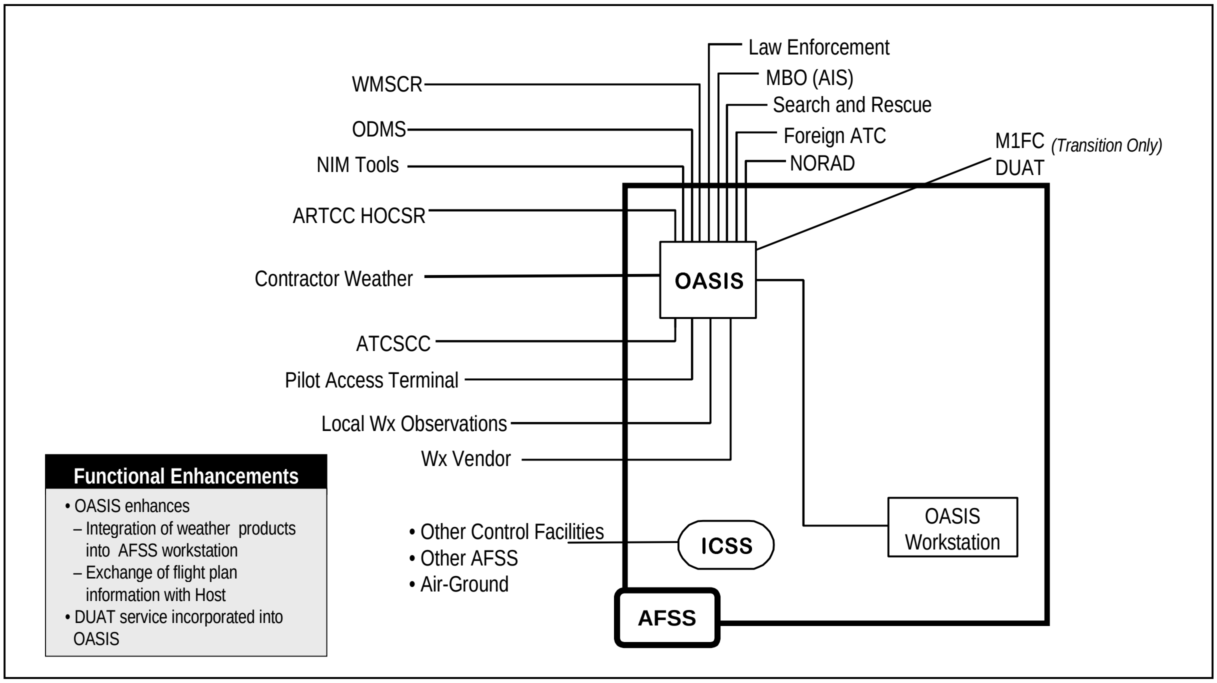

Figure 25-2. Flight Services Architecture—Step 2 (1999–2005)

search and rescue support) will ultimately become the principal focus of the flight service specialist.

Late in the period, enhanced local information sharing will be implemented in OASIS to provide data storage and data sharing according to the NAS-Wide Information Service (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

25.1.3 Flight Services Architecture Evolution—Step 3 (2006–2015)

Retrieval of information in AFSSs will be quicker as the ability to exchange information with other facilities matures by the middle of Step 3 (see Figure 25-3). In this step, flight plans will be replaced by the flight object (see Section 19 for additional details about the flight object). The flight object contains the pilot's known flight path or profile, the discrete identification code, and all information necessary to initiate SAR if needed. This information is available throughout the NAS. For aircraft equipped with satellite navigation systems and using ADS-B, the NAS-wide information network will have the capability to automatically identify a successful landing, close a flight plan inadvertently left active in the system, or provide last known position.

Access to and retrieval of flight planning information will be continuously available to users and service providers via the NAS-wide information network. The following information will be available:

- Current SUA status
- Current NAS infrastructure status
- Predictions of traffic density based on the current flight trajectories filed and active in the system
- Current or planned route structure revisions needed to alleviate demand imbalance or avoid hazardous weather.

By the middle of Step 3, flight service automation will be fully integrated into the NAS-wide information network (see Figure 25-3). Access to flight planning and flight filing information by users will be via this network. FSS specialists will provide information to aircraft in flight, as necessary, predominately via data link.

Connectivity between the AFSS and other facilities will migrate to the NAS-wide information network. The integrated communications switching system (ICSS) infrastructure will transition to digital technology and the voice switch replacement system (VSRS). Air-ground voice commu-

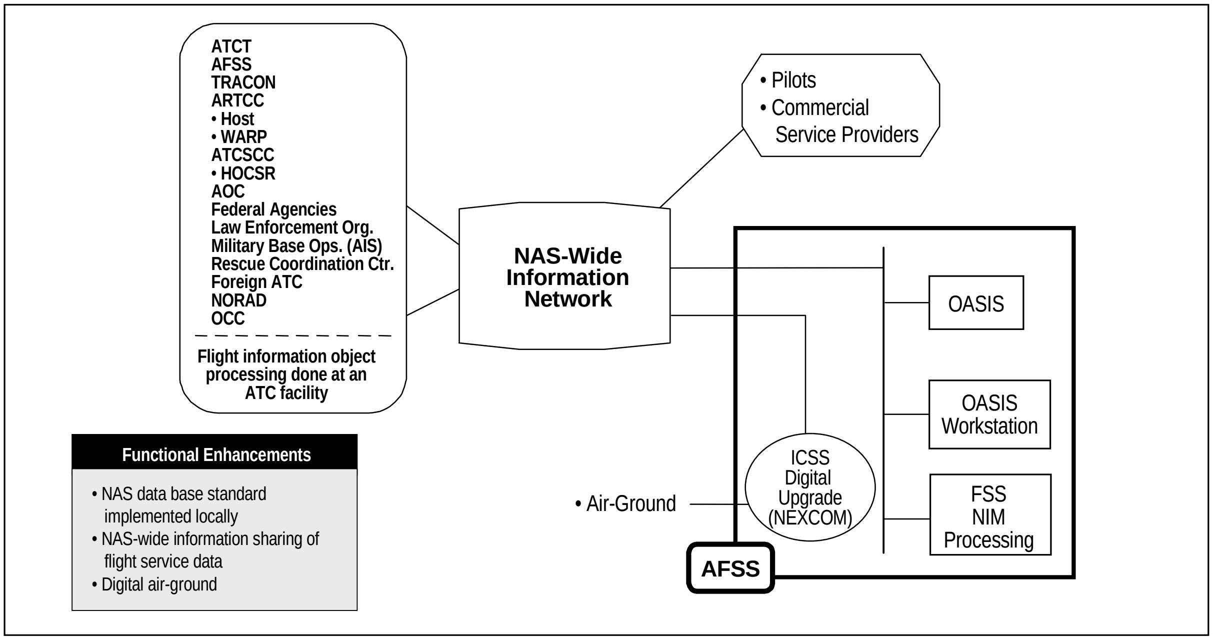

Figure 25-3. Flight Services Architecture—Step 3 (2006–2015)

nications will be provided via the next-generation air-ground communications system (NEXCOM) operating in analog mode. Transition to digital mode will depend on user equipage (see Section 17, Communication).

As the flight plan is formulated, the planner will reference the network data base for information about current and predicted weather conditions, traffic density, restrictions, and status of SUAs. When the flight plan is filed, it is automatically checked against actual and predicted NAS conditions. Potential problems will be displayed automatically to the planner or user and flight plan alternatives will be provided.

During the middle of Step 3, flight service research efforts will be implemented as OASIS is upgraded. These tools include decision support systems (DSSs) to assist preflight planning and suggest alternate routes in the event of hazardous weather, conflicts with SUA use, and in response to NOTAMs and other NAS constraints. Research initiatives realized during this period involve improvement of SAR support services by incorporating aircraft identification and position received from an emergency locator transmitter (ELT), referenced to the Global Positioning System (GPS) into NAS data bases, enhancing SAR support. Other research efforts will help determine the criteria for implementing the time-based trajectory flight profile (flight object) that will eventually replace the flight plan.

25.2 Summary of Capabilities

OASIS replaces obsolete FSAS equipment and software. It also incorporates the functionality of DUAT service and GWDS. Commercial enterprises will likely continue to be active in providing preflight services for a fee.

With full implementation of the NAS-wide information network, NAS users everywhere can access distributed data bases of weather, NOTAMs, SUA information, and the flight object. By virtue of making the distributed data bases readily accessible, this network greatly enhances various FSS functions such as route de-conflicting, self-briefing, and SAR services. In this flight services architecture, users and providers rapidly acquire any information they need, and flight services become a shared responsibility of the flight service specialist, the pilot, and commercial vendors. Figure 25-4 summarizes the evolution of flight services capabilities.

25.3 Human Factors

Flight service functions are not expected to change dramatically as new information automation systems are put into service. However, there

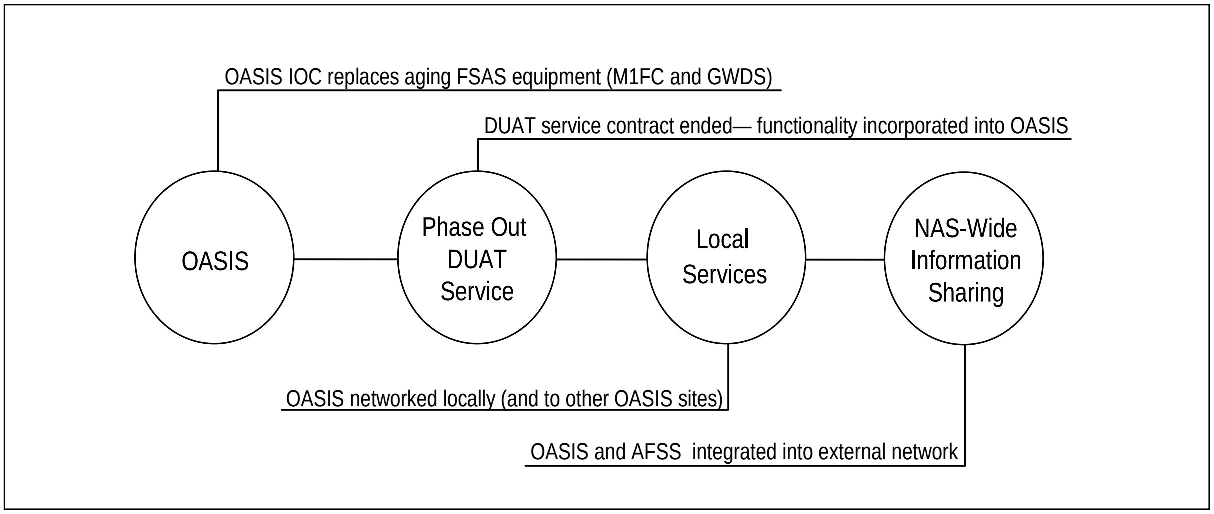

Figure 25-4. Flight Services Capabilities Summary

will be a change in the specialists' focus toward providing services to those without direct access and those needing additional assistance. While the introduction of OASIS is expected to improve the human interface and eliminate many of the problems encountered with the current system, future systems will provide flight service specialists and users with enhanced situational awareness by increasing the quality of service provided. The human factors effort will ensure that specialists have the required information displays and distribution tools, training, and procedures to enhance flight services. This effort will focus on:

- Improving automation capabilities for pilots to receive and use critical flight and weather information from multiple NAS facilities, especially when airborne
- Designing information displays and distribution methods and procedures to increase pilots' (and flight service providers') situational awareness and interpretation of available data
- Coordinating human factors standards for display and distribution among international elements to harmonize aeronautical information, flight trajectory data, and traffic density
- Conducting simulations to devise procedures (and training) for real-time trajectory information updates for improved traffic prediction and management

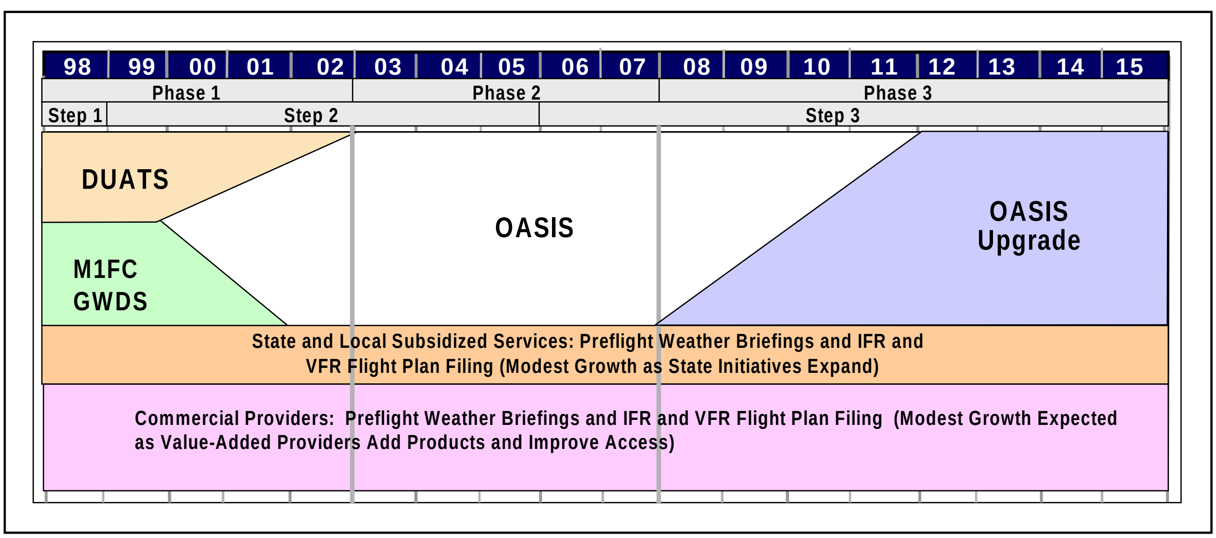

Figure 25-5. Flight Services Transition

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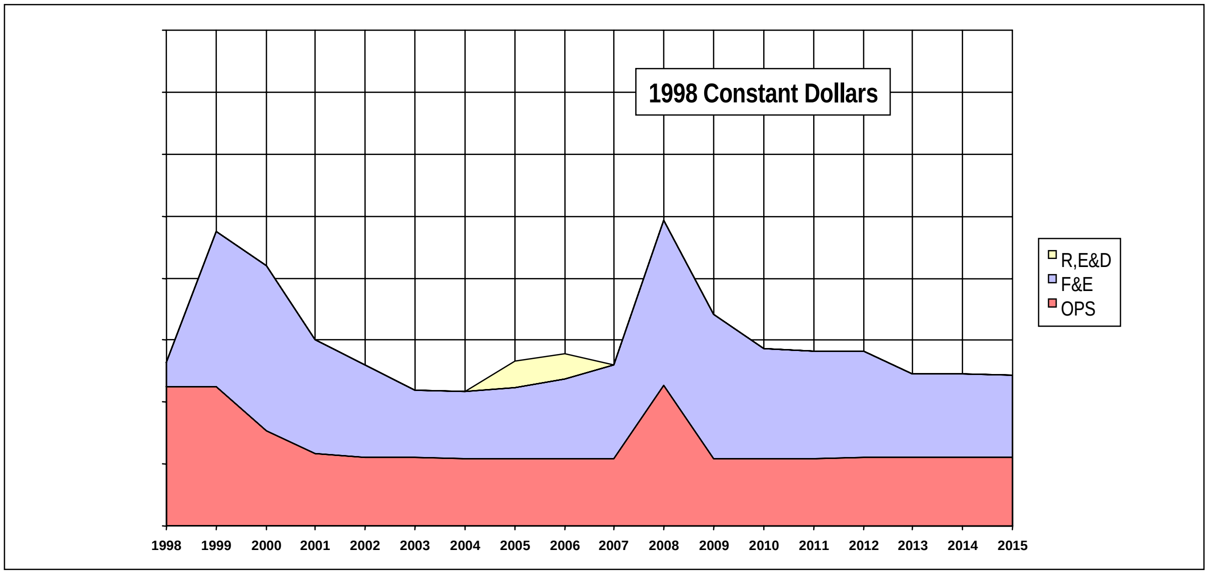

Figure 25-6. Estimated Flight Services Automation Costs

- Designing error-tolerant decision support tools and interactive aids that facilitate user collaboration in obtaining and using NAS flight planning and flight profile information.

25.4 Transition

The flight services transition is depicted in Figure 25-5. The major transition milestones are:

- Existing M1FC/GWDS is replaced by OASIS.
- DUAT service is phased out as its functionality is incorporated into OASIS.
- Local information services are enhanced.
- FSAS is fully integrated into the NAS-wide information network.

25.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for flight services from 1998 through 2015 are presented in constant FY98 dollars in Figure 25-6.

25.6 Watch Items

Implementation of OASIS will enhance pilots' ability to self-brief and file flight plans directly, which will require a reevaluation of the roles and responsibilities of FSS specialists.

26 AVIATION WEATHER

Weather information services are critical to NAS safety and efficiency. According to the National Research Council (NRC) report[1] on Aviation Weather Services, from 1988 to 1992 one-fourth of all aircraft accidents and one-third of fatal accidents were weather-related. The 1996 Nall Report[2] states that 69 percent of all weather-related general aviation (GA) accidents resulted in fatalities. The 1997 Aviation Capacity Enhancement Plan reveals that from 1992 to 1996, adverse weather was a major factor affecting NAS capacity, accounting for 72 percent of system delays greater than 15 minutes.

Aviation weather capabilities in the NAS must undergo major changes. The changes will convert today's weather architecture—consisting of separate, stand-alone systems—to one in which future weather systems are fully integrated into the NAS under the weather server concept (single-sourced data shared with all systems). The weather architecture evolves further as it progresses from a "weather server" concept (serving primarily the en route and terminal domains) to one that supports all NAS users, with the implementation of the NAS-wide information service. Integration into this information exchange allows the weather architecture to exploit communications enhancements and provide near simultaneous delivery of weather data and products to both users and service providers.

As a result, NAS providers and users receive the same hazardous weather information (with system-tailored depiction) *simultaneously*, enhancing common situational awareness. This facilitates collaborative decisionmaking for traffic flow managers, controllers, flight service specialists, and pilots. This is accomplished by two new weather systems that convert multiple sources of "raw" weather data into meaningful information: the integrated terminal weather system (ITWS) and the weather and radar processor (WARP). These systems act as weather servers providing information to other subsystems and users. In addition, communications enhancements (i.e., flight information services (FIS) data link) will improve the data exchange between the ground and the cockpit.

26.1 Weather Architecture Evolution

The NAS weather architecture optimizes the capability to collect and process weather data, provide current and forecast conditions of hazardous and routine weather, and disseminate that information in text and/or graphical formats to all NAS users and service providers. NAS users include pilots who receive preflight and in-flight weather information, flight planners, air traffic control (ATC) specialists, airline and vendor meteorologists, and airline dispatchers. Service providers include ATC personnel, traffic flow managers, and flight service specialists. This capability enhances safety and capacity by promoting common situational awareness.

The NAS weather architecture features an evolution to fully integrated systems enhanced by the maturation of the NAS-wide information service (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

NAS weather architecture systems are categorized as either (1) *sensors* and/or *data sources* or (2) *processing and display systems*. In some cases, a system will process and display data and also be the source of weather data for other NAS systems (e.g., ITWS). The four-step evolutionary process for implementing the NAS weather architecture is discussed in Sections 26.1.1 through 26.1.4.

26.1.1 Weather Architecture Evolution—Step 1 (1998)

The current weather architecture is depicted in Figure 26-1. This diagram and the following weather architecture diagrams are generic depictions of NAS facility/subsystem connectivity. In the upper left section of the diagram are the

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1. "Aviation Weather Services, A Call for Federal Leadership and Action," National Aviation Weather Services Committee, Aeronautics and Space Engineering Board, Commission on Engineering and Technical Systems, and National Research Council Report, National Academy Press, Washington, D.C., 1995, p 10.
2. *Nall Report, Accident Trends and Factors for 1995,* The Aircraft Owners and Pilots Association Air Safety Foundation, 1996, p. 13.

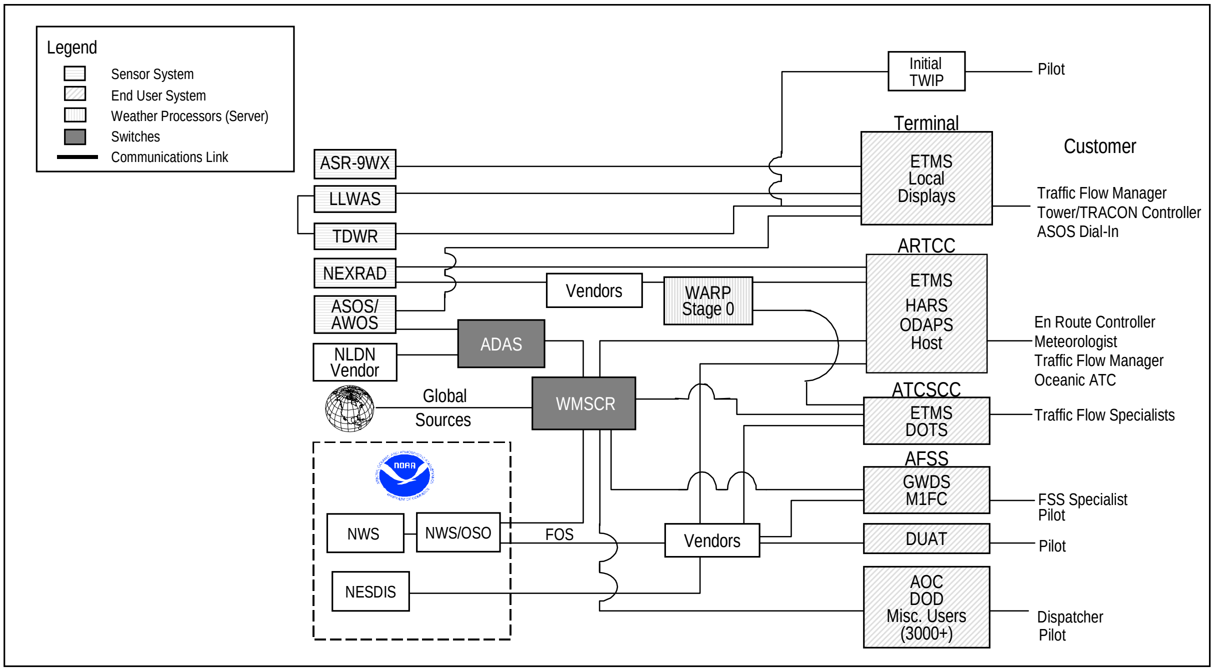

Figure 26-1. Weather Architecture Evolution—Step 1 (1998)

weather sensors that collect the raw data. At the lower left section of the diagram are the outside agencies that provide the majority of weather information to the NAS—the National Weather Service (NWS) and the National Environmental Satellite, Data, and Information Service (NESDIS). The NWS and NESDIS are offices of the National Oceanic and Atmospheric Administration (NOAA). In the center of the diagram are the weather switches, which the FAA uses to transport data. The weather processors are also included in the center section. Finally, on the right side of the diagram is the ultimate user of the data. In the diagrams, the flow of weather data is from left to right as it moves into and through the NAS.

Sensors and Data Sources

Weather data are obtained from ground-based sensors, aircraft sensors, and commercial vendors. Surface observations are generated manually by observers or automatically by the automated weather observing system (AWOS) and automated surface observing system (ASOS). The AWOS data acquisition system (ADAS) collects, processes, disseminates, and archives observations from AWOS and ASOS for local and national distribution. Using data from the National Lightning Detection Network (NLDN), ADAS generates and sends lightning activity messages to AWOS and ASOS for reporting use.

The next-generation weather radar (NEXRAD) provides a variety of weather data, in the areas covered, including layered radar reflectivity data associated with severe weather such as tornados and hail, areas of precipitation, wind speed and direction, and turbulence.

The ground-based low-level windshear alert system (LLWAS) and the terminal Doppler weather radar (TDWR) detect localized windshear phenomena such as microbursts, while windshear detection systems on commercial jetliners provide airborne detection. In the terminal area, thunderstorm information can be inferred from TDWR and by primary airport surveillance radar (ASR), as well as by NEXRAD. In the en route environment, weather radar data from NEXRAD, primary air route surveillance radar (ARSR), and NLDN are used to provide this information.

NOAA support includes observations (surface and aloft), aviation advisories such as significant meteorological information (SIGMET) and airmen's meteorological information (AIRMET), terminal and en route forecasts, radar data, and satellite data. The National Center for Environmental Prediction (NCEP) is a collection of NWS centers that are responsible for atmospheric model development and forecast output. NCEP models provide analyses of current weather and forecast weather parameters such as wind and temperatures aloft, which are required by NAS users. The NWS distributes the data to vendors who provide these data to the FAA.

The NWS's Aviation Weather Center (AWC) uses a computer model to generate forecasts of aviation hazards such as icing. The AWC works closely with both the FAA Aviation Weather Research (AWR) Program and air traffic operations to improve forecasting tools. The AWC's forecasts of aviation-impact variables (icing, turbulence, and convective activity) mitigate the effect of hazardous weather on the NAS. A large portion of weather data used within the NAS is produced or collected by NOAA (i.e., NWS and NESDIS). Additionally, most third-party weather products find their origins in NWS-provided data and models.

The FAA uses terminal weather information for pilots (TWIP) to provide commercial pilots with direct access to limited weather information via the aircraft communications addressing and reporting system (ACARS) data link. This enables pilots of equipped aircraft to view a rough depiction of hazardous weather that is similar to the ones displayed to the tower and the terminal radar approach control (TRACON) controllers, greatly improving common situational awareness. Currently, TWIP is available only from TDWR sites.

Processing and Display

Weather information is processed and displayed in the various ATC facilities through separate weather systems. In air route traffic control centers (ARTCCs), these include the WARP Stage 0 and the NEXRAD principal user processor, which are used by meteorologists in center weather service units (CWSU) and traffic management units. In control towers and TRACONs, information from TDWR, LLWAS, and ASOS are usually provided on separate displays. Some integration of weather data into automation systems currently exists as the host computer processes ARSR weather data that are displayed in two intensity levels to en route controllers (see Section 21, En Route). Additionally, the automated radar terminal system (ARTS) displays ASR reflectivity data to TRACON and tower controllers (see Section 23, Terminal). Three terminals (Dallas-Ft. Worth, Memphis, and Orlando) currently have an ITWS prototype. National implementation of ITWS will begin in Step 2, providing short-term forecasts of terminal-impacting weather to controllers in TRACONs and towers.

At the Air Traffic Control System Command Center (ATCSCC), weather data are obtained from the aircraft situation display (ASD), NEXRAD, and command center WARP briefing terminals. Flight service specialists use the flight service automation system (FSAS), consisting of the Model 1 Full Capacity (M1FC) (see Section 25, Flight Services) plus the interim graphic weather display system (GWDS).

The weather message switching center replacement (WMSCR) is the primary NAS interface with the NWS telecommunications gateway (NWSTG) for the exchange of aviation alphanumeric and limited gridded weather products. WMSCR collects, processes, stores, and disseminates aviation weather products to major NAS systems, the airlines, and international and commercial users.

WMSCR also provides storage and distribution of domestic notice to airmen (NOTAM) data and retrieval of international NOTAMs through the Consolidated NOTAM System. WMSCR receives weather and NOTAM information from the DOD via the Automated Weather Network (AWN); severe weather information from AWC; observations from ADAS and the U.S. Air Force's automated weather information distribution system (AWIDS); international data via the aeronautical fixed telecommunication network (AFTN); and weather information from WARP and FSAS through the aviation weather processor. The WMSCR is also an integral part of the operational alphanumeric product backup for the NWS's automation of field operations and services (AFOS) communications network when the NWSTG is nonoperational.

26.1.2 Weather Architecture Evolution—Step 2 (1999–2002)

The weather architecture completes the deployment of two major systems during this time period, WARP and ITWS (see Figure 26-2). WARP will undergo software upgrades and produce re-

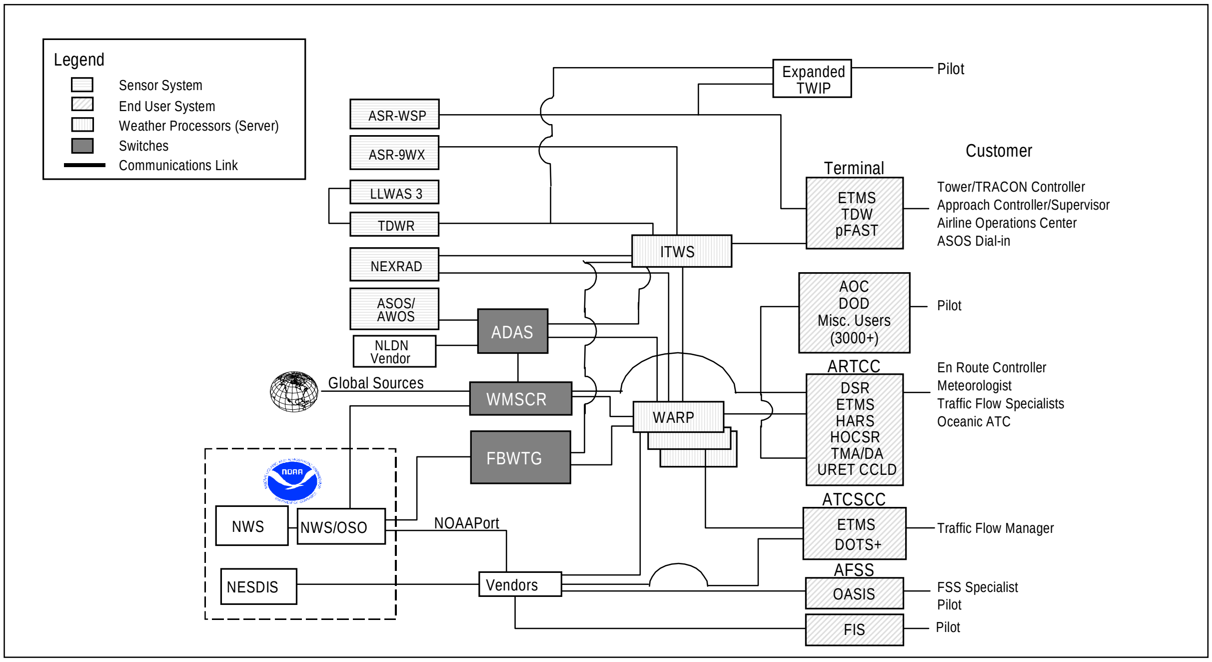

Figure 26-2. Weather Architecture Evolution—Step 2 (1999–2002)

gional and national mosaics of NEXRAD data. These mosaics will be displayed on display system replacements (DSRs) to controllers. WARP will also interface with the Operational and Supportability Implementation System (OASIS) and NAS automation systems, such as the User Request Evaluation Tool core capability limited deployment (URET CCLD) and the Center TRACON Automation System (CTAS) traffic management advisor (TMA). ITWS will be implemented during this period and provide enhanced terminal weather data forecasts to tower and TRACON personnel, as well as to NAS automation systems at 45 TDWR-equipped airports. ARTCC traffic managers will have an ITWS situation display enabling them to track storm activity at major airports and to facilitate coordination with the TRACONs and major hubs.

Other changes include the following: conversion of the NEXRAD radar product generator (RPG) to an open systems architecture; implementation of the FAA bulk weather telecommunications gateway (FBWTG); deployment of OASIS; and fielding of the airport surveillance radar-weather systems processor (ASR-WSP). ASOS and the ASOS Lightning Detection and Reporting System (ALDARS) deployment will be completed. TDWR upgrades include improvements to gust-front algorithms and equipment modifications.

As part of the NAS modernization schedule, the FAA will implement Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) as a risk-mitigation effort for subsequent national deployment of various automation systems designed to provide user benefits. WARP will support URET CCLD by providing forecasts of gridded wind and temperature data fields for trajectory calculations. Other FFP1 CCLD automation systems requiring weather data include the CTAS pFAST used by terminal controllers and traffic managers, and the TMA used by en route controllers and traffic managers. WARP Stage 3 implementation will be accelerated to provide this support.

As part of the FAA's flight information services (FIS) policy, the FAA will approve the basic weather data that a commercial service provider will provide to the cockpit. FIS provides the weather information needed by pilots to operate safely and efficiently. The National Aeronautics and Space Administration (NASA) and industry are engaged in joint research to provide "weather-in-the-cockpit." NASA will expend considerable research funds to develop aviation weather information systems to provide current data to airline and general aviation aircraft.

Sensors and Data Sources

The FAA will continue to obtain weather data from internal and external sources in Step 2. Current FAA sensors will be upgraded or replaced for sustainment. Airborne observations will improve as the airlines equip additional aircraft with weather sensors and increase the number of parameters reported (such as humidity and turbulence). NOAA will be the source of various data, including gridded forecast data from the NCEP (i.e., the Environmental Modeling Center (EMC) and the AWC) satellite data from NESDIS, as well as forecasts and observations from NWS Weather Forecast Offices. Some “value-added” products continue to be provided by vendors. The WMSCR continues to receive and transmit much of the alphanumeric weather information.

The FAA upgrades the basic weather sensors, leading to improved reliability, increased accuracy, and superior maintainability. An example of this refinement is the NEXRAD system upgrade. The NEXRAD network is upgraded to an open systems architecture with new hardware, software, and a modular configuration. The upgrade to the NEXRAD radar product generator (RPG) increases processing capabilities and accuracy and improves both reliability and maintainability. The upgraded system incorporates more complex algorithms. As science advances its understanding of meteorological processes that affect aviation, new products and services will be added to NEXRAD. ASOS will receive sensor and processor upgrades, thereby enhancing its capabilities.

The AWC disseminates forecasts of weather affecting aviation operations to the NAS in a gridded format. This gives NAS systems the capability to display aviation-impact variables, such as icing, in a format that is advantageous to users. For instance, a SIGMET report will no longer be available only in text format with an area location, but will also be provided in gridded data fields. This allows the location and extent of the significant (or hazardous) weather to be displayed graphically in four dimensions (including time). The AWC also provides forecasts of convective activity, icing, turbulence, and AIRMETs as gridded data fields.

There are a number of developmental projects sponsored by the AWR Program that are ready for implementation during this time period.

Processing and Display

Within the weather architecture, ITWS and WARP will function as NAS weather servers—WARP in the en route domain and ITWS in the terminal domain. As weather servers, WARP and ITWS “ingest” NWS computer model output, as well as acquire and process data from sensors such as the NEXRAD and TDWR.

These servers then generate and disseminate weather products to the NAS automation systems, such as CTAS TMA and enhanced traffic management system (ETMS). These systems use 3-dimensional wind and temperature forecasts, as well as convective weather data, to project activity and traffic flow and to allow for a more efficient use of airspace. Wind forecasts are used by URET CCLD to facilitate sequencing of air traffic by en route controller teams.

ITWS will be deployed by the end of Step 2. ITWS improves safety by providing a windshear and microburst prediction capability in the terminal area and improves management of runway resources when convective storms and gust fronts are present. Terminal controllers and traffic managers can more efficiently sequence aircraft in and out of terminal airspace by using wind shift predictions.

ITWS provides information on significant weather associated with severe storms and facilitates routing aircraft around hazardous weather by processing data from LLWAS-3, TDWR, airport surveillance radars (ASR-9), and NEXRAD. LLWAS-2 will continue to provide windshear and microburst information at those terminal sites (about 39) without TDWR and ASR-WSP. ITWS will process the six-level weather data from the ASR-9 to remove anomalous propagation and ground clutter. Removal of anomalous propagation and ground clutter from controller displays is essential, as it is often indistinguishable from actual weather. Initially, ITWS data will be displayed to terminal and tower controllers on separate displays. TWIP functionality will be moved to ITWS and enhanced by adding ITWS data to improve the accuracy of available weather information. TWIP will expand to include ASR-WSP sites at the end of this period.

As the en route weather server, WARP processes and displays NEXRAD data for use by ARTCC controllers and meteorologists. WARP creates a regional NEXRAD mosaic that is also provided to the ATCSCC and other facilities. WARP will incorporate NWS higher-resolution forecast data, which will improve forecast accuracy. Another benefit is the capability to provide controllers with time and position data on moving weather systems for traffic planning and flow control.

The new automation systems being deployed by the FAA require the NWS's improved, higher-resolution forecast data. The FAA is working closely with the NWS to develop the FBWTG. The FBWTG (see Figure 26-2) will enable the high-speed transmission of high-resolution, gridded weather forecasts between the NCEP and the NAS. The planned deployment of the first phase of the FBWTG is early in Step 2.

In addition to the current LLWAS and TDWR sensors, a weather system processor (WSP) enhancement for the existing ASR-9 will be deployed, adding a windshear and microburst detection capability. The ASR-WSP processes the six-level weather data and provides windshear and microburst products similar to TDWR.

ASR-WSP supports airports without a TDWR that need improved windshear and microburst detection capability. Like TDWR, ASR-WSP will provide a TWIP capability, thereby extending the area coverage of windshear systems providing data to pilots.

26.1.3 Weather Architecture Evolution—Step 3 (2003–2008)

Early in Step 3, WMSCR will be upgraded to improve capacity and enhance its capabilities. WARP will provide weather data to Multi Center TMA and DA. The major change in Step 3 will be the interface to the NAS-wide information network, which begins late in this step (see Figure 26-3); for more detailed information, see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing. This network will allow weather systems in the terminal and en route environments to freely share data and products.

At this time, the FAA will make NAS status and existing weather data available to private data link service providers for the development of FIS products. Commercial providers may make basic

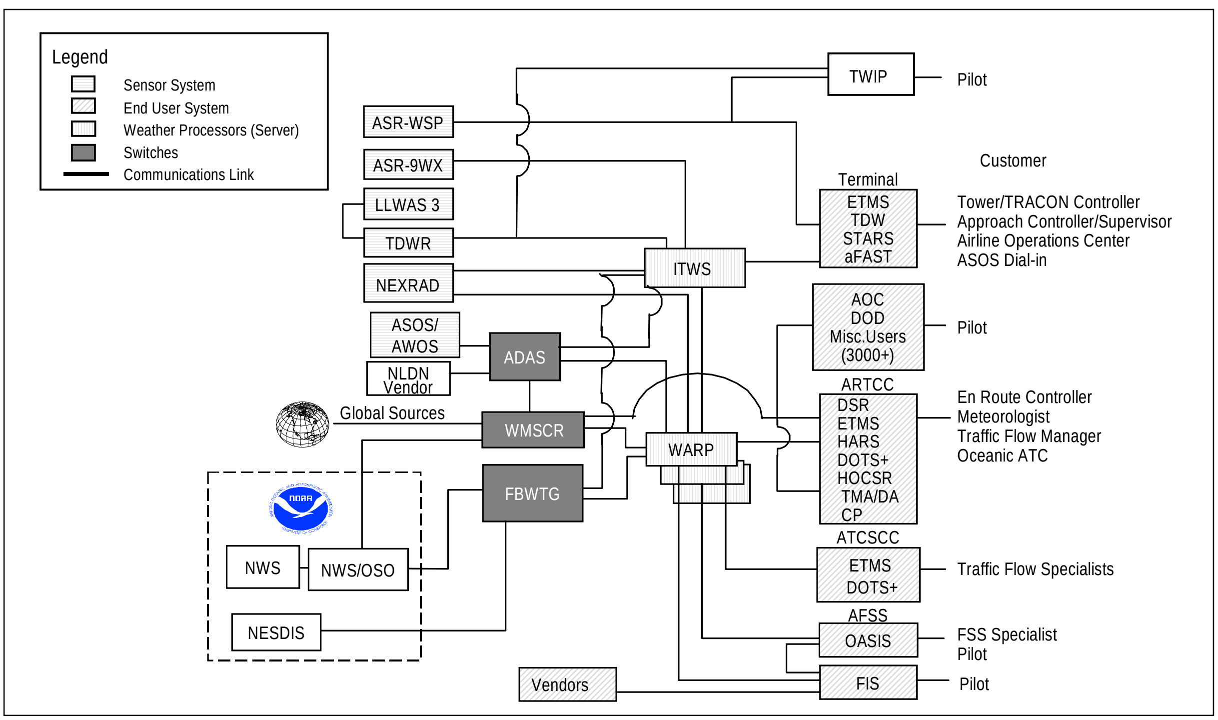

Figure 26-3. Weather Architecture Evolution—Step 3 (2003–2008)

FIS products available, at no cost to the government or the user, and may make "value-added" products available for a fee.

Sensors and Data Sources

NEXRAD will continue evolving to an open systems architecture through the upgrade of the radar data acquisition (RDA) module. The NWS will continue to improve the accuracy of the forecast models used by the FAA. New products, including the predictive locations for hazardous weather, are being introduced into NEXRAD, and improvements in AP removal algorithms continues.

The NWS will continue to upgrade current sensors, thereby enhancing and expanding the capability to automatically provide accurate observations. Lightning detection will be improved to include all forms of lightning, not just the current cloud-to-ground strikes. Aircraft functioning as sensors of weather data will become a key element in improving the accuracy of weather forecast models and will validate new algorithms.

The NAS-wide information service will enable the FBWTG to interface more effectively with the NAS. Weather satellite data will also be available via the FBWTG.

Processing and Display

The ITWS will undergo a technology refresh that incorporates weather satellite data and implements algorithms for vertical windshear, storm growth and decay, icing aloft in the terminal area, in-flight icing, and runway visual range (RVR)/ visibility and ceiling predictions. The goal is to expand ITWS predictive capability beyond 30 minutes (to several hours). The modular design allows ITWS enhancements to be used at more terminals. Some ITWS algorithms could be used at second-level airports running on a local processor or an ITWS variant. ITWS data will be displayed to controllers on the Standard Terminal Automation Replacement System (STARS) workstations in TRACONs and towers as part of the STARS preplanned product improvement (P^3I). ATCSCC traffic managers will receive ITWS data, enabling them to track storm activity at major airports and to facilitate coordination with TRACONs and major hubs.

Weather-in-the-cockpit products transmitted via FIS in this time frame may include improved weather radar information, hazardous weather advisories, observations and forecasts, winds and temperatures aloft, gridded forecast data, and pilot reports (PIREPs). These data are tailored to provide a "high-glance" value display of significant weather along the flight path. Different types of users can still expect varied levels of support; full graphical display of high-resolution data in the cockpit is the ultimate goal.

New algorithms will transition to the NWS for incorporation into their forecast models. A new icing forecast technique is scheduled to be incorporated into AWC's SIGMET and icing forecasts. Additionally, the NAS will receive finer resolution data from the NWS, thereby improving ITWS and CTAS pFAST products.

As the NAS-wide information service is deployed and as new methods of distributing weather data develop, WARP will transition away from its role as an en route weather server within the ARTCC. WARP and ITWS will remain collectors and processors of data, but will require less direct interfaces to user systems with the implementation of the information exchange service. Data will reside on distributed data bases, so it will not always be necessary to directly interface with ITWS or WARP—only with the information exchange network.

26.1.4 Weather Architecture Evolution—Step 4 (2009–2015)

ITWS and WARP will continue to produce new and improved weather products to support other NAS systems (see Figure 26-4). As the demand for products continues to grow and become more complex, these systems will evolve. In addition, the WARP hardware will be replaced and new algorithms will be added, increasing its capabilities. As the NAS-wide information service matures, it will incorporate the WMSCR functionality.

Weather-in-the-cockpit will be improved as new products are able to be transmitted via the FIS data link. These products include freezing level, wake turbulence, ceiling/visibility, and volcanic ash cloud forecasts. The addition of the gridded products from ITWS and WARP will require higher bandwidth data link and advanced avionics

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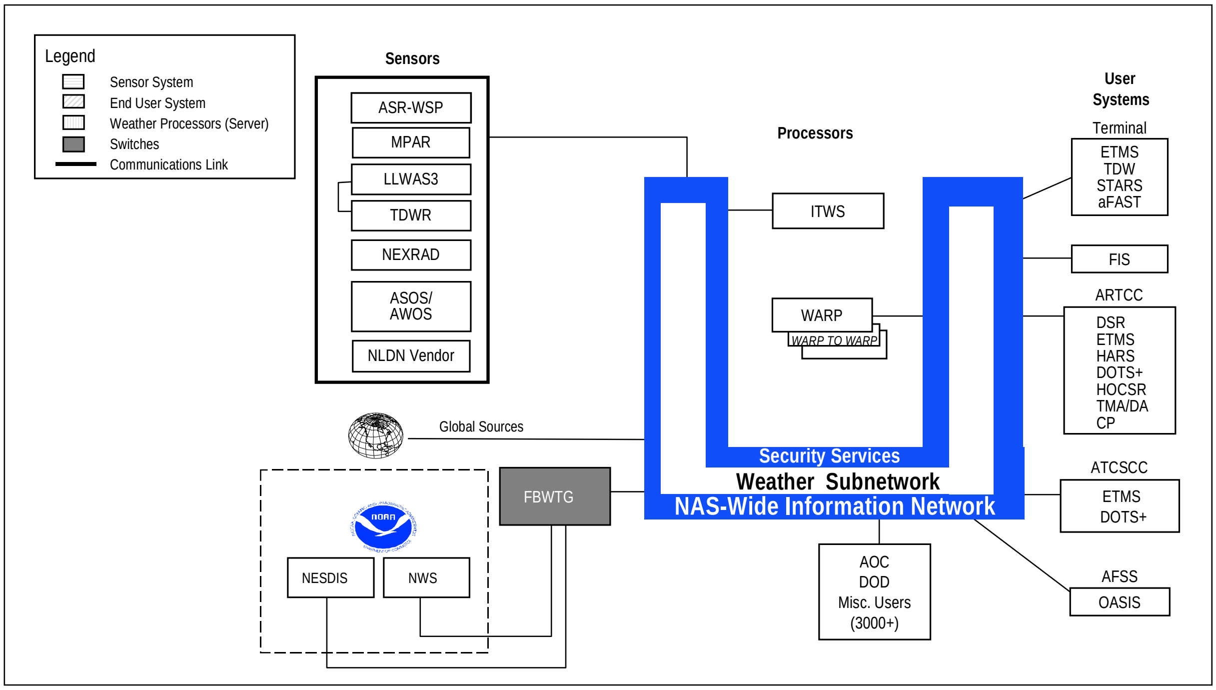

Figure 26-4. Weather Architecture Evolution—Step 4 (2009–2015)

to fully exploit the available information. The flight plan will become a flight object, and the system will automatically inform the pilot via FIS of any significant or hazardous weather. FIS data link and avionics will be more capable and cost-effective during this time frame.

The FAA will continue to use the AWR Program and leverage its affiliation with research agencies to improve the safety and capacity of the NAS by improving algorithms within existing systems. Results from the FAA's wake vortex research program will be implemented, thereby increasing the understanding of vortex behavior, leading to possible reduction of separation standards (see Section 10, Research, Engineering, and Development). Additionally, these algorithms will be ported to processors/systems at airports where it is cost-effective.

Sensors and Data Sources

The next generation of airport surveillance radar will detect both aircraft and windshear events. A multipurpose airport radar (MPAR) will be deployed late in Step 4 that will replace ASR-9s and -11s, LLWASs, and TDWRs. MPAR provides improved maintainability and reliability while reducing spectrum demand and environmental impacts. (see Section 16, Surveillance).

Processing and Display

The NAS-wide information service enables more efficient data searches and queries for all NAS users for any type of data to improve the collaborative decisionmaking process. This information exchange network allows all NAS users to be updated simultaneously, in near real-time when hazardous weather occurs and ensures that all weather products are maintained in a common data base. FIS capability will be improved to transmit enhanced data to the cockpit for display of significant weather. ITWS will receive a technology refresh, allowing it to support multiple terminal sensor configurations.

In the cockpit, the pilots see the same data as other NAS users and can query the weather data base to obtain additional information.

26.2 Summary of Capabilities

The NAS weather architecture will undergo evolutionary changes over the next 5 to 10 years, enhancing its capability to collect numerous types of weather data from internal as well as external sources, then process and disseminate tailored weather products to both NAS users and providers. Figure 26-5 depicts these enhanced capabilities chronologically. In 1997, the first stage of WARP was implemented nationally. CWSU me-

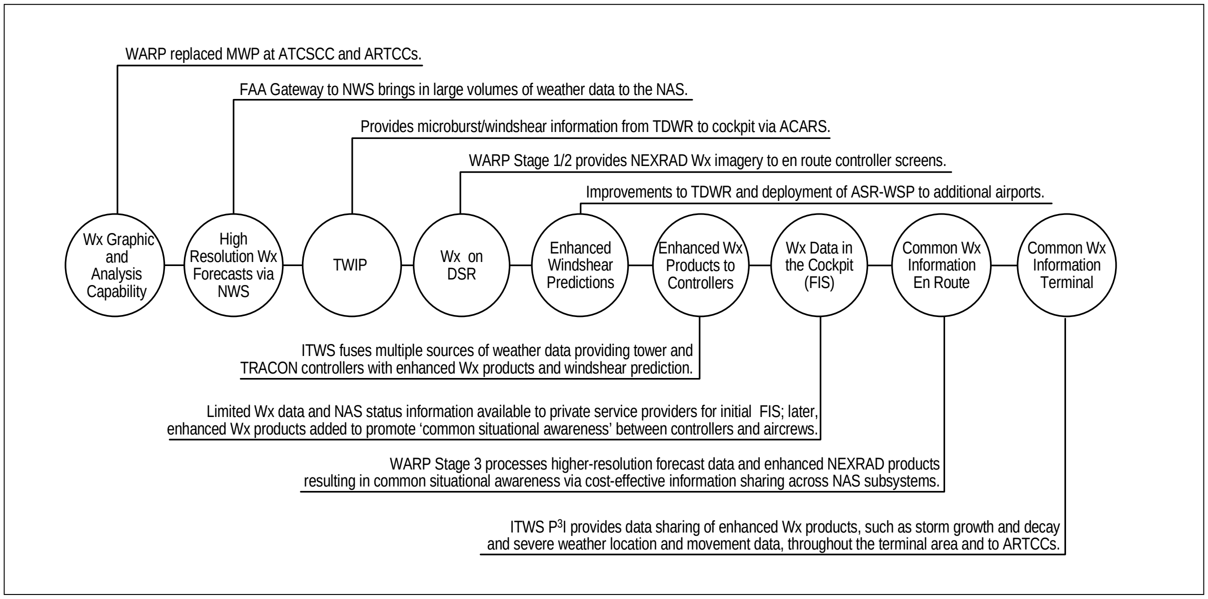

Figure 26-5. Aviation Weather Capabilities Summary

teorologists now have upgraded graphical display and analytical capabilities and can provide better weather support to controllers and traffic flow managers in the ATCSCC and the ARTCCs.

Almost immediately, the NAS will receive high-resolution forecasts of weather data from the NWS. Implementing the high-speed communications link (i.e., FBWTG) between the NWS and the FAA will provide high-definition, high-quality, gridded weather products to the NAS. These high-resolution data sets contain more accurate forecasts of weather information, such as winds and temperature and of aviation-impact variables such as in-flight icing. This enables controllers and traffic managers to plan for aviation-impacting weather.

TWIP currently provides microburst and windshear information from TDWR to commercial aircraft cockpits via ACARS. With the addition of ASR-WSP sites, TWIP coverage will be expanded.

As part of the FAA's FIS policy, the FAA will provide NAS status and existing weather data (including some WARP and ITWS products) to a commercial service provider for data link to the cockpit.

About the same time, en route controllers will see weather from NEXRAD overlaid on their displays as WARP Stages 1 and 2 interface with the DSR. This will help controllers assist aircrews in avoiding hazardous weather. It also eliminates the need for weather data from long-range radar, which allows selected sites to be decommissioned. Traffic managers will use weather information from their WARP briefing terminals for contingency planning. In support of FFP1 CCLD, WARP accelerates Stage 3 interfaces to prototype URET CCLD, ETMS, and CTAS TMA/pFAST sites to provide higher-resolution wind and temperature data.

Early in the modernization process, NEXRAD will be completely converted to an open system architecture, increasing its product generation and dissemination capabilities to fully exploit the radar data. ITWS and WARP will receive improved radar products.

ITWS deployment will be completed shortly thereafter, vastly improving the FAA's ability to monitor atmospheric phenomena in the terminal domain. ITWS provides accurate forecasts of wind shifts associated with frontal passage, thereby mitigating their effect on capacity. ITWS also enhances safety with its windshear prediction capability.

WARP will be connected to other users, completing Stage 3 implementation. This permits tailored products to be shared by NAS users and service providers. Additional algorithms will enhance

NWS forecast data and improve NEXRAD radar products.

ITWS will incorporate new algorithms, enhancing its capability to forecast events such as storm growth and decay, ceiling and visibility, RVR, runway winds, and turbulence.

26.3 Human Factors

The primary focus of human factors related to aviation weather is the efficient and effective presentation of weather products to the meteorologist, dispatcher, controller, and pilot. Of key importance will be determining the informational requirements at various locations and recognizing the possibility that these needs may be different for different classes of aircraft and different service provider locations. To assist aircraft most effectively, controllers will need to know the precise location of an aircraft and which weather products are available to the pilots.

Future systems will move away from separate controls and displays for individual subsystems, therefore, human factors efforts must focus on developing integrated displays and controls, in which weather products are one element of a larger presentation. Human factors will be a major factor in designing integrated workstations. The information needed by controllers must be presented in a timely manner so that workload is maintained within acceptable limits.

Lastly, as the FAA moves toward Free Flight, more information will be needed by the pilot and the controller, particularly for GA aircraft operations. Appropriate training will need to be developed to ensure that pilots and service providers can effectively use the weather information that is presented.

26.4 Transition

The transition schedule for the major components of the aviation weather system is shown in Figure 26-6. The principal transitions include:

- FBWTG Phase 1 deployed
- WARP Stages 1 and 2 deployed (NEXRAD on DSR)
- NEXRAD open system upgrade to RPG
- ITWS deployed
- ASR-WSP deployed
- NEXRAD open system upgrade to RDA
- Satellite data via FBWTG Phase 2
- ITWS products on STARS displays

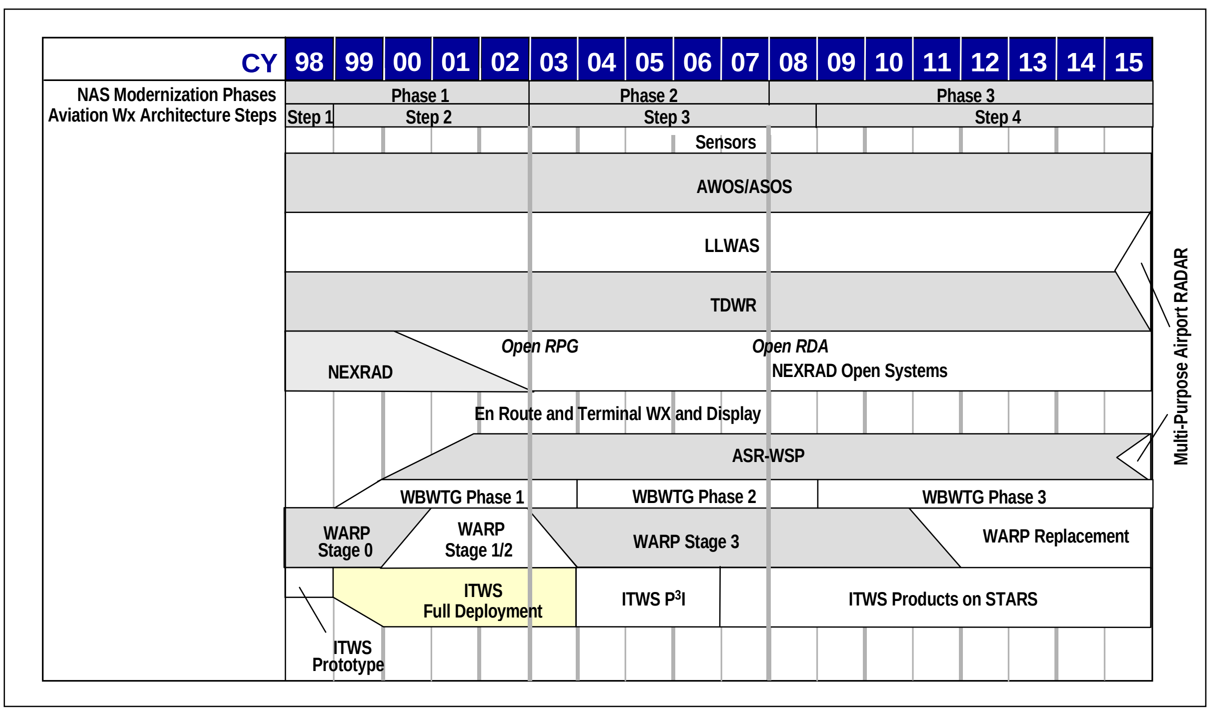

Figure 26-6. Weather Systems Transition

- FBWTG Phase 3 upgrades for NAS-wide information service compatibility
- Consolidated terminal and weather radar deployed (MPAR) (see Section 16, Surveillance).

26.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for aviation weather architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 26-7.

26.6 Watch Items

Several items are critical to the aviation weather architecture. These include adequate radio frequency spectrum for ASOS and AWOS, tri-agency funding for NEXRAD upgrades, and implementation of private service provider FIS.

- Without adequate radio frequency spectrum for ASOS and AWOS, pilots cannot receive surface weather observations for new ASOS and AWOS locations.
- Tri-agency (FAA, DOD, and NWS) ability to fund and implement NEXRAD system upgrades in a timely manner, enabling WARP, ITWS, and OASIS to receive FAA-specific products.
- FIS implementation dependent upon available frequency spectrum and commercial service provider participation.

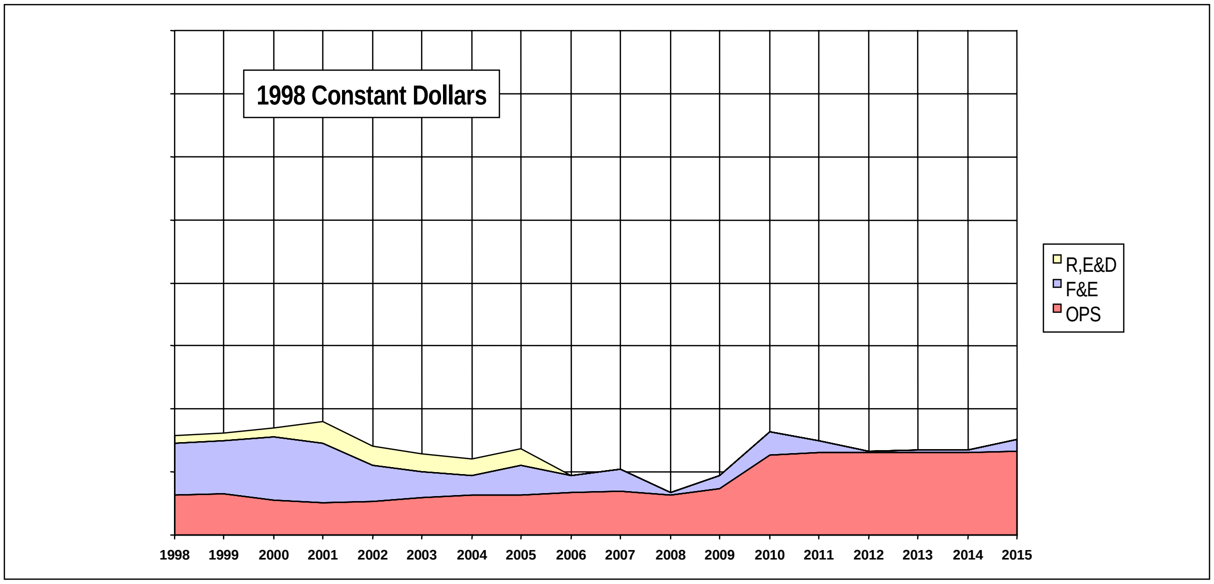

Figure 26-7. Estimated Weather Systems Costs

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27 INFRASTRUCTURE MANAGEMENT

Today's NAS infrastructure includes more than 30,000 air traffic control (ATC) systems. These infrastructure systems, which continue to increase in number faster than the Airway Facilities (AF) workforce that maintains them, include communication, surveillance, navigation and landing, weather sensors, and air traffic automation decision support systems (DSSs). NAS infrastructure systems support the air traffic operations carried out at air traffic control towers (ATCTs), terminal radar approach control (TRACON) facilities, air route traffic control centers (ARTCCs), airports, and other facilities. It is imperative that the performance of these systems be maintained to preserve the integrity of the NAS infrastructure and thereby avoid delays or disruptions in air traffic.

AF's greatest strength is the technical expertise of its workforce, its dedication to excellence, and the resulting level of public trust. The NAS infrastructure management (NIM) philosophy—which stresses decisionmaking alliances composed of AF elements and the AF customer base—has been initiated. AF operations business will be based on the NIM philosophy.

This philosophy embodies a strong customer orientation with an emphasis on cost-effectiveness and efficient and effective delivery of air traffic services. This concept, described in the *Airway Facilities Concept of Operations for the Future*, March 1995, represents a fundamental shift in the FAA's focus from the decentralized equipment maintenance performed today to centralized *service* management. The concept responds to anticipated changes in the NAS environment by promoting:

- Partnerships with organizations, both within and external to the FAA, to promote customer and stakeholder inclusion in setting strategic and tactical directions
- A strong customer orientation to ensure that AF is doing the right things, in a timely manner, to meet end-to-end customer service delivery needs
- A flexible, integrated information infrastructure to support the anticipation, identification, decisionmaking, and resolution of problems before service quality is affected
- A more expert workforce to exploit the full potential of emerging technologies and work "smarter" in meeting increased customer needs while maintaining workforce resources
- An emphasis on cost-effectiveness through a more businesslike approach to costs, measured performance, and focused resources.

A NIM capability combining technology, organizational changes, and reengineered processes will support the real-time information exchange essential to progress toward FAA/industry collaborative decisionmaking and the economics of implementing such concepts as Free Flight. NIM supports free flight through improved NAS service availability.

Implementing the infrastructure management philosophy will enable the FAA to provide more efficient and effective management of a growing NAS, reduce the NAS mean time to restore, and increase the productivity of the AF workforce, thereby improving air traffic services.

NIM implementation tools will be based on proven state-of-the-art systems management concepts in which functions are distributed among the central management servers, agents, and the managed resources themselves. NIM tools will use industry-standard computing platforms, information structures, and communication interfaces. The system technology will include commercial off-the-shelf (COTS) client/server platforms and applications that support industry standard management interfaces with open application program interfaces, standard data base technology, and interfaces for data sharing with other DSSs.

NIM tools build upon the remote maintenance monitoring system (RMMS) by leveraging existing assets and providing new automated management capabilities. Through NIM tools, the FAA will be able to remotely detect system faults and remotely resolve many faults. Collecting and analyzing more detailed fault and performance data will support proactive management of the NAS infrastructure. NIM capabilities will include remote monitoring and control; NAS modeling; and event, fault, maintenance, performance, resource, voice and data communications, and security management. The combination of new technology, organizational changes, and reengineered processes will enable the FAA to contain infrastructure maintenance costs while ensuring a consistently high level of service.

27.1 Infrastructure Management Architecture Evolution

The NIM phased implementation approach is based on the managed evolutionary development (MED) concept, which requires demonstrated performance before progressing to the next phase. Actual infrastructure management will be accomplished in four steps.

Step 1. Step 1 involved enhancing the RMMS by establishing remote monitor and control capabilities to nearly 4,000 remote NAS facilities. Initial stages of integration included development of a prototype NIM, which provided for a concept evaluation and investigated future development capabilities.

Step 2 (NIM Phase 1). During Step 2, an initial NIM capability will be incrementally deployed. Selected system service components (SSCs) (i.e., the National Operations Control Center (NOCC), operations control centers (OCCs), service operations centers (SOCs), national network control centers (NNCCs), work centers (WCs), and mobile system specialists capabilities) will be established during this time frame.

At the beginning of this step, NIM capabilities will be installed at four of the NIM SSCs, the NOCC, and the three OCCs. Prior to the beginning of final operational capability (FOC), resource management capabilities will be installed at all NIM SSCs. At this point, NIM will include new COTS-based resource management capabilities and legacy RMMS-based enterprise management capabilities. Full NIM resource and enterprise management capabilities will be operational at all SSCs by FOC.

Step 3 (NIM Phase 2). During Step 3, capabilities will be expanded and refined.

Step 4 (NIM Phase 3). Advanced NIM capabilities will be implemented, including intelligent fault correlation, reliability-centered maintenance, predictive maintenance, and NAS-wide information sharing.

27.1.1 Infrastructure Management Architecture Evolution—Step 1 (1996–1997)

The initial step in the evolution of infrastructure management consisted primarily of organizational changes, including consolidating management and maintenance facilities and acquiring and fielding advanced maintenance tools for operations support specialists. The RMMS is the primary automation system supporting NAS infrastructure operations during this step (see Figure 27-1). An integral part of the RMMS is the maintenance control center (MCC). AF's Maintenance Automation 2000 MCC operations concept focused on centralizing the management of maintenance operations for facilities at the sector level. These decentralized sectors operate and maintain equipment and facilities within their domain of responsibility based on local requirements and priorities. The MCC uses automation tools in a limited capacity to assess equipment performance, obtain real-time facility status information, perform remote facility certifications, and dispatch personnel as needed to accomplish facility/service restoration.

The heart of the RMMS network consists of 22 maintenance processor subsystems (MPSs) located within the ARTCCs. An additional MPS is located at the NIM premier facility (NPF) in Herndon, Va., which is co-located with the National Maintenance Control Center (NMCC), part of the ATC System Command Center. Using two resident software applications—the maintenance management system (MMS) and the interim monitoring and control system (IMCS)—maintenance personnel located in the MCCs remotely monitor the status of selected NAS subsystems, log maintenance actions, and report service and facility interruptions and equipment failures. The MPS also schedules preventive system maintenance actions and enables remote certification of facilities and equipment. Each MPS is capable of supporting up to four MCCs. The MPSs interface with NAS subsystems through a monitoring system function, which is either embedded or external to those subsystems. Some NAS subsystems provide their own monitoring/management and are known as element management systems.

Maintenance specialists at MCCs and at more than 300 work centers throughout the United

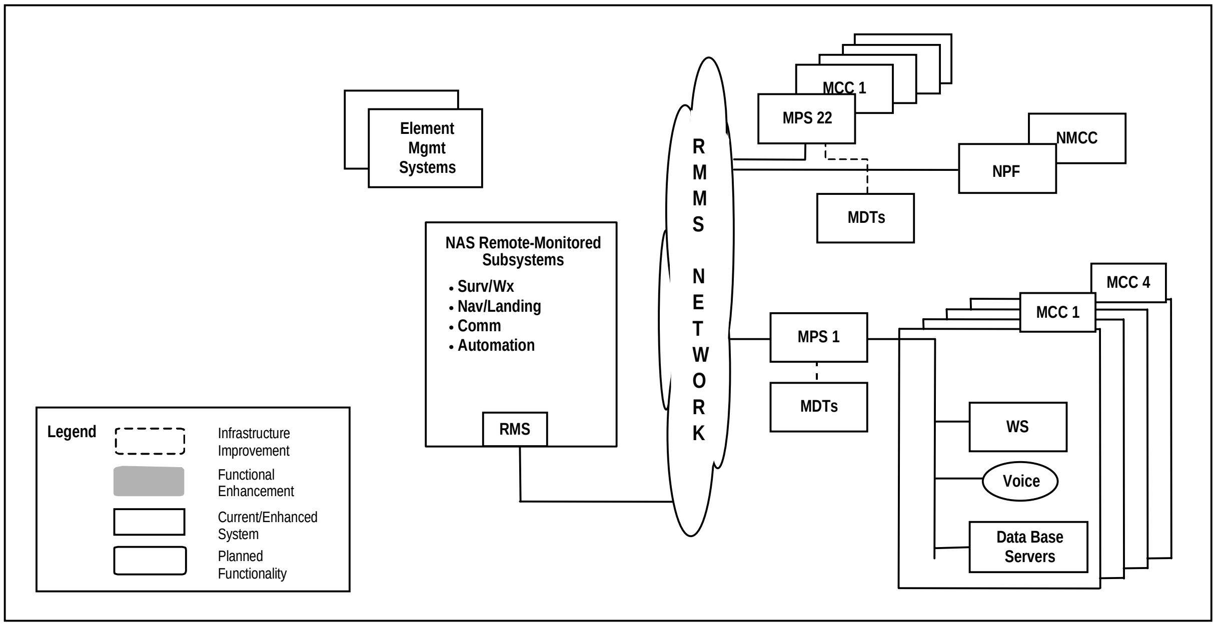

Figure 27-1. Infrastructure Management Architecture Evolution—Step 1 (1996–1997)

States have the primary responsibility for maintaining the NAS subsystems. Additionally, many remote facilities have permanent, onsite maintenance operations personnel due to their critical role in providing NAS services.

During Step 1, selected MCCs established prototype facilities for NIM concept evaluation and development capabilities.

27.1.2 Infrastructure Management Architecture Evolution—Step 2 (1998–2002)

The major activity at the beginning of Step 2, which is Phase 1 of the NIM implementation, was the opening of the NPF in June 1998. The NPF is used for demonstrations, training, and the development of new business processes, policies, and procedures. Initially, the NPF has demonstrated Build 1 and Build 2 of the NIM capabilities and will be able to continue the development of new business processes, policies, and procedures. In this step, the NPF will demonstrate the NIM Phase 1 initial operational capabilities that will be used at the NOCC, NNCCs, OCCs, SOCs, and WCs and by the mobile specialists. The major emphasis of NIM is on resource management. During this time frame, monitoring and control functions in the NPF will use the legacy system capabilities—the RMMS and element management systems.

The infrastructure management architecture for Step 2 (see Figure 27-2) is based on a three-tiered operations concept in which communications between tiers is provided via a local services network. NIM will consist of nodes located at one NOCC, two national network control centers (NNCCs), three OCCs, about 50 SOCs, and more than 300 WCs. The NOCC and OCCs will be responsible for centralized management of the NAS infrastructure.

NOCC. The NOCC is the operations control center that monitors the delivery of NAS infrastructure services to users and customers from a national perspective. It provides 24-hours-a-day, 7-days-a-week monitoring of infrastructure status and event response via OCC-reported information. The NOCC reports significant NAS infrastructure events to senior FAA management and coordinates transmittal of information to customers concerning events that could affect them. It monitors and assesses activities aimed at restoring services that have a critical affect on customers. Trend analysis such as the health of the NAS and NAS operational financial data will be available for FAA management analysis and reporting purposes at the NOCC.

OCCs. The primary role of each OCC is to manage the NAS infrastructure within its domain of responsibility. It directs the maintenance of NAS

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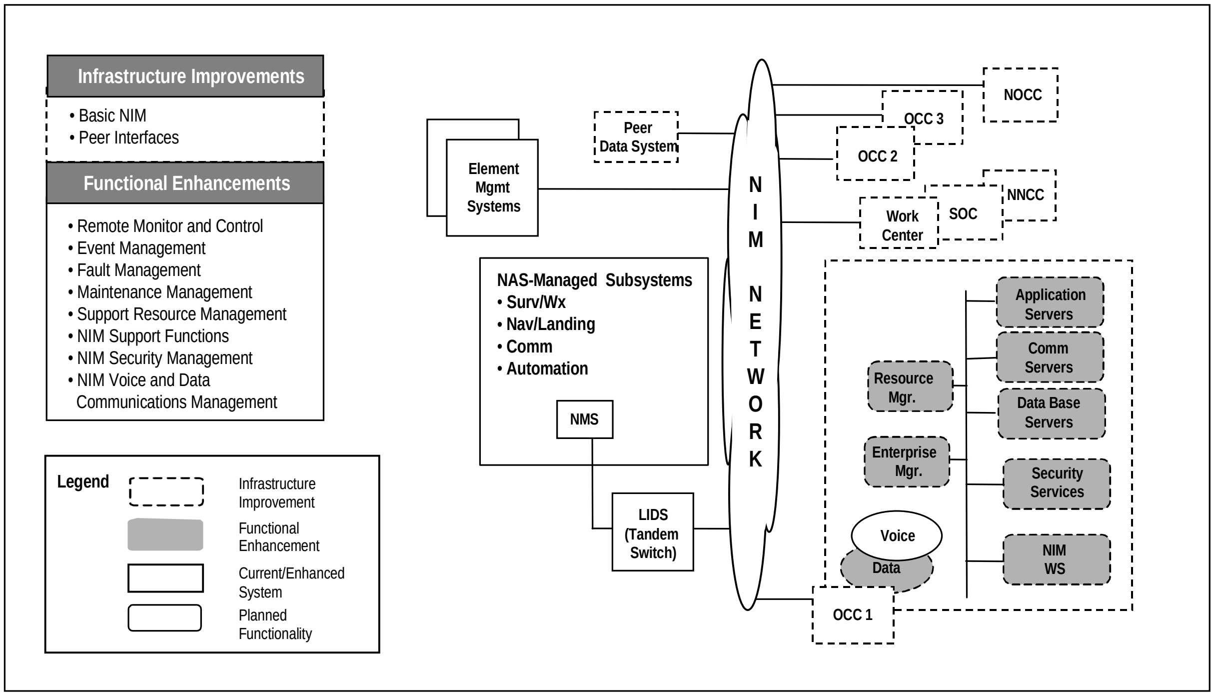

Figure 27-2. Infrastructure Management Architecture Evolution—Step 2 (1998–2002)

services and systems, providing active response and problem resolution. To accomplish this, each OCC operates 24-hours a day, 7 days a week, responding to faults and continuously monitoring the delivery of services and the status of the systems and equipment supporting those services. OCCs exercise operational control of their assigned domains of responsibility and oversee multiple work centers. Each OCC will be capable of assuming the responsibility of any other OCC that fails or is unable to provide services.

WC/SOC. The primary role of the WC is to maintain designated airways facilities. Each work center supervises its assigned workforce, ensures response to tasking, and is responsible for the equipment in specific geographic areas. SOCs are WCs that provide an AF presence at a high-impact facility when it has been determined that on-site coverage is necessary for efficient and effective delivery of service either to the facility or within a limited geographic area surrounding the facility. High-impact facilities include NNCCs, ARTCCs, large TRACONs, and ATCTs with significantly high numbers of operations. Operations support specialists will be provided with updated desktop and portable maintenance data terminals (MDTs). Cellular and satellite telephones and pagers will be used to supplement existing communications systems.

NNCCs. The primary role of the NNCCs is to monitor and control selected nationwide area telecommunications networks and to interface with the NOCC, OCCs, SOCs, and leased service providers to provide real-time operational status information. In addition, the NNCCs will interface with the appropriate OCCs for workforce and resource assignments during any planned or unplanned outages of NNCC-managed elements.

During Step 2, the MPS will transition to the Tandem switch, which is part of the legacy information distribution system (LIDS). RMMS functionality will be absorbed by the NIM resource manager located at the OCCs. Initially, IMCS functionality will transition to the maintenance automation system software (MASS) monitor and control function, which will reside in LIDS. By the end of Step 2, a COTS enterprise manager will be introduced. The interim and final enterprise managers will be capable of performing in an open operating system environment. The existing RMMS will be enhanced with an open system capability through LIDS. NIM tools and the enhanced RMMS will be collectively identified as NAS managed subsystems (NMSs). At the end of

Step 2, more than 6,000 NMSs will be automatically interfaced with the enterprise manager.

During Step 2, information from the logistics inventory system (LIS), corporate information management system (CIMS), regional information system (REGIS), and notice to airmen (NOTAM) will be available for NIM.

Basic functional capabilities included in Step 2 include:

- *NAS Modeling*: Define relationships between NAS elements, associate a criticality level to each resource, and provide tools to maintain a data base of the relationships
- *Remote Monitor and Control:* Remotely collect and process status information from NAS infrastructure resources, define authorized users, and establish access control to the commands
- *Event Management:* Classify and type events, and track NAS maintenance activities
- *Fault Management:* Generate alarms and alerts and manage actions to resolve the events that caused the alarms
- *Maintenance Management:* Match available maintenance resources with tasks that need to be completed
- *Support Resource Management:* Maintain information on the status of all resources required to support the NAS
- *NIM Support Functions:* Log, archive, and analyze NIM tool operational data
- *Security Management:* Protect NIM tool data via user identification, authentication, and access control mechanisms; support NAS-wide security management, such as detecting and logging NAS infrastructure security violations for reporting to FAA management
- *Manage NIM Voice and Data Communications:* Ensure appropriate communications capabilities at each user position.

27.1.3 Infrastructure Management Architecture Evolution—Step 3 (2003–2005)

Step 3 of the evolution, which is Phase 2 of the NIM implementation (see Figure 27-3), capitalizes and improves on the Phase 1 investment through the application of managed evolutionary development (MED). It will integrate existing element management systems, monitor environ-

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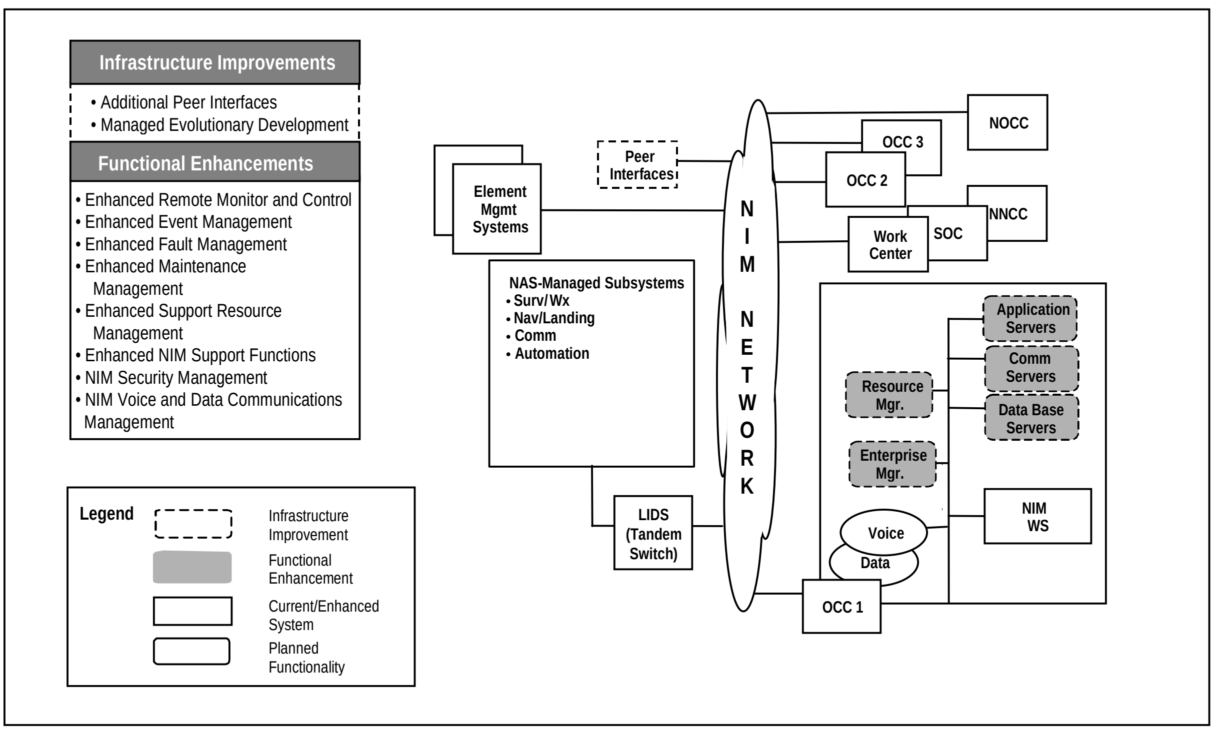

Figure 27-3. Infrastructure Management Architecture Evolution—Step 3 (2003–2005)

mental systems, and expand local information exchange services within the NAS.

The synergistic effect of integrating all resource management functions and the enterprise management function will result in seamless service management. Service management will improve services and reduce associated costs from both an individual or component service perspective and a multiservice perspective. The sum of multiple services forms the end-to-end service delivered to AF customers.

27.1.4 Infrastructure Management Architecture Evolution—Step 4 (2006–2015)

Step 4 of the evolution, which is Phase 3 of the NIM implementation (see Figure 27-4), will refine the capabilities provided in Steps 2 and 3 through continued application of MED. It will also initiate intelligent fault correlation, reliability-centered maintenance, predictive maintenance, enhanced information sharing with NIM tool internal and external users, and continued connection of new and legacy systems.

27.2 Summary of Capabilities

NAS infrastructure management development, through the process of MED, is leveraging the FAA's investment in the RMMS into a performance-based management system, which is focused on managing the NAS infrastructure so customer services are based on established performance standards, customer expectations, and business objectives. Following establishment of an initial RMMS capability in Step 1, each subsequent step in the evolution builds on the procurement of proven COTS products. Step 2 builds on the existing RMMS and establishes the three-tiered operations concept by:

- Establishing NOCC, OCC, and SOC/WCs
- Establishing a modern information infrastructure featuring resource and enterprise management, including security
- Establishing external interfaces with selected peer systems
- Increasing the number of remotely monitored and controlled NAS facilities
- Replacing technologically obsolete MDTs used by AF specialists
- Supplementing existing fixed communications capabilities with mobile communications equipment and services for AF specialists.

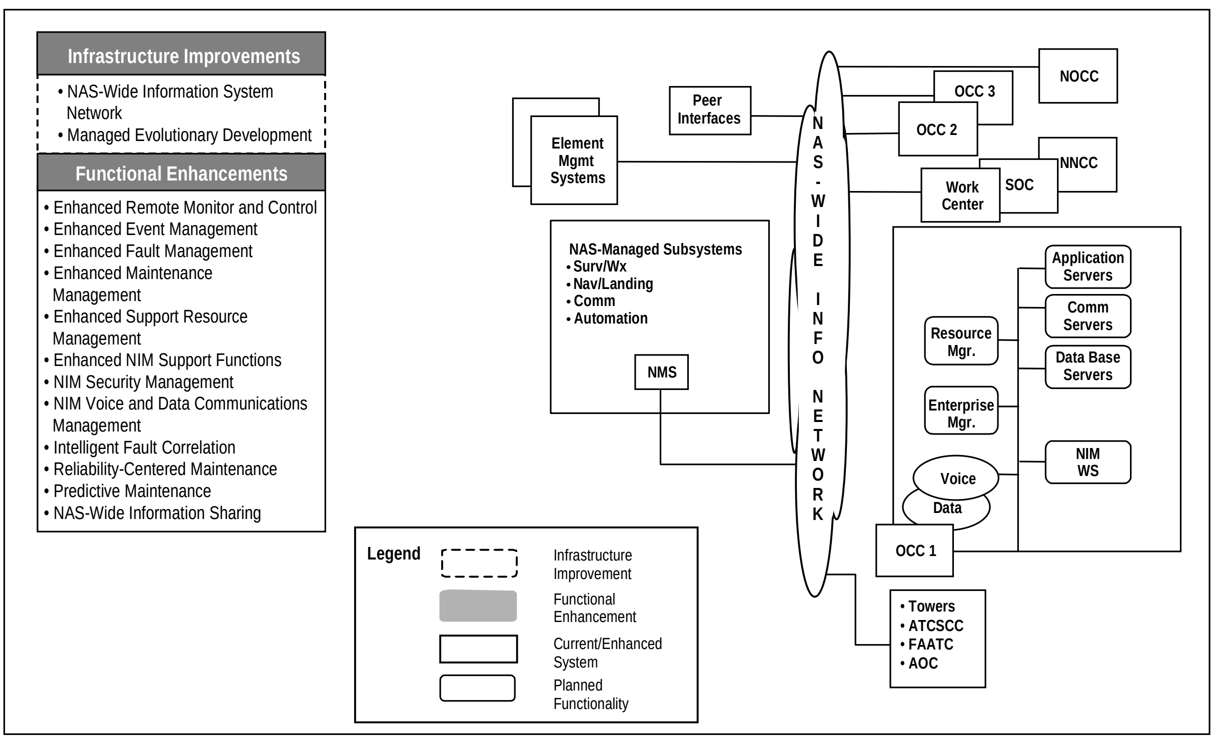

Figure 27-4. Infrastructure Management Architecture Evolution—Step 4 (2006–2015)

Step 3 continues the modernization and refinement of Step 2 capabilities while Step 4 initiates intelligent fault correlation (i.e., reliability-centered maintenance and predictive maintenance as well as enhanced information sharing). Step 4 also continues life-cycle modernization and refinement of NIM capabilities. As emerging technologies mature and become readily available, NIM will incorporate new functional capabilities yet to be identified throughout this final phase of its life cycle.

27.3 Human Factors

Human factors planning for NIM tools involve defining a process for incorporating human factors engineering into the development, acquisition, implementation, and operation of the control and work centers that comprise NIM, as well as for its associated equipment, capabilities, facilities, and personnel. For many years, the number of subsystem-specific interfaces technicians use in maintaining the NAS has steadily increased. These interfaces include diverse displays, keyboards, and controls with different computer-human interface (CHI) characteristics. NIM tools will incorporate a human-centered workstation design to enhance efficiency and effectiveness. The goal of NIM tool human factors engineering is to make the most effective use of human capabilities and to minimize the effects of human limitations and errors on the performance of the system.

The NIM will center on adapting and integrating components and subsystems that are developed using fast-track methods, including acquisition of COTS/nondevelopmental item (NDI) hardware and software products. The application of human factors criteria to subsystem selection will provide systems that better support users. As subsystem capabilities are developed, a subsystem's operational suitability will be determined through operational test and evaluation. The subsystem will be systematically assessed in terms of human factors requirements, criteria, measures, and procedures.

Because training provides people with needed knowledge and skills, it directly affects system performance and is a critical human factors issue that will be considered in detail. The training program must reduce training time through more efficient training methods and impart a wider scope of technical knowledge and skills to a reduced workforce. Because training can be very costly over a system's service life, and its delivery affects the availability of personnel for conducting operational tasks, it is considered to be an integral part of the system engineering design process. Traditional training will be augmented with other job performance aids.

NAS personnel requirements are determined by system equipment design, procedures, training, NAS workload, and other factors. Human resource tradeoff studies will be conducted to examine staffing requirements in relation to system productivity.

27.4 Transition

The schedule for the NIM implementation is shown in Figure 27-5. This schedule will be revised after requirements are stabilized.

27.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for the infrastructure management architecture in constant FY98 dollars for 1998 through 2015 are shown in Figure 27-6.

27.6 Watch Items

Enforcement of FAA Order 6000.30. With the onset of user-intensive concepts such as Free Flight, maintaining the integrity of the NAS infrastructure while using such advanced technologies as NIM tools takes on added importance. However, liberal interpretation of FAA Order 6000.30 (Policy for Maintenance of the NAS Through the Year 2000) has resulted in many instances of noncompliance with the intended maintenance policy, thereby negating the benefits to be gained from NAS-wide implementation of an infrastructure management system. More stringent adherence to the AF CONOPS, with added emphasis on improving the integrity of the NAS infrastructure and the resulting benefits to the user community, is imperative.

Agreement on NIM Requirements. More work is needed to define requirements and operational procedures for using remote, automated control of NAS assets. Operational concepts need to be de-

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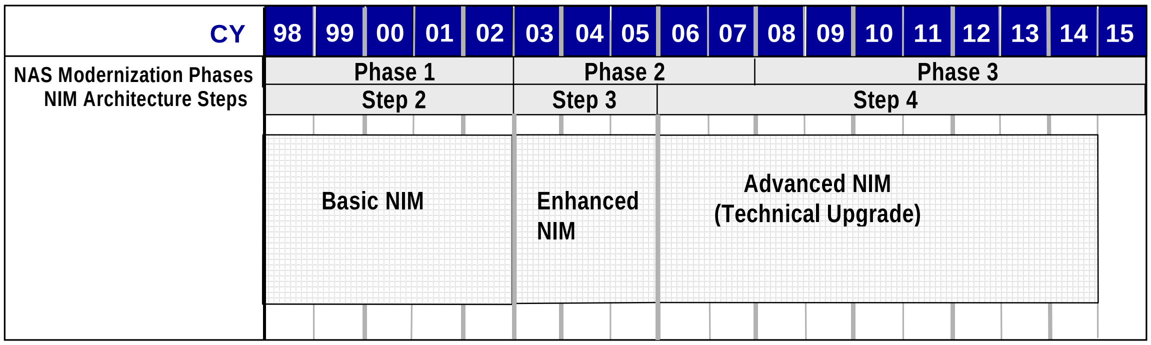

Figure 27-5. Infrastructure Management Transition

fined and modeled to assess workload improvements.

Implementation of NAS-Wide Security. NIM tools interface with all other NAS systems, and access to it must be restricted. For this reason, management and control of NAS security services is included in the NIM architecture. Within NIM tools, INFOSEC requirements are based on the NIM protection profile and vulnerability assessment. Adequate security is ensured for NIM tools by meeting requirements for service availability, access control, authentication, nonrepudiation, confidentiality, and integrity. In particular, appropriate security gateway services are available to provide proper access control between NIM tools and the NAS-wide information network. This reinforces consideration of NIM tools when it comes to planning for collection of NAS-wide subsystem security data for reporting and auditing purposes and to perform NAS-wide intrusion detection and key management.

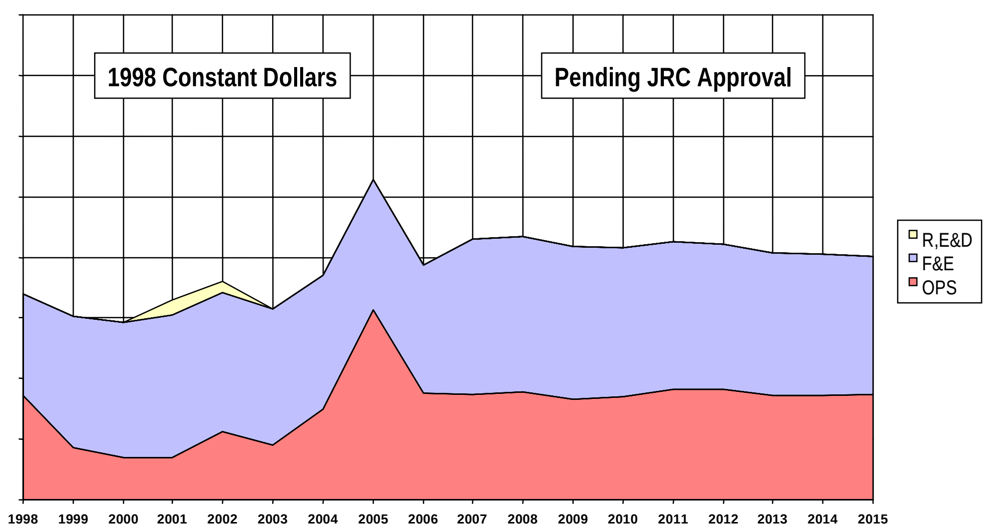

Figure 27-6. Estimated Infrastructure Management Costs

28 AIRPORTS

The airport is a key component of the NAS, and this section addresses the architecture from an airport operator's viewpoint, focusing on aircraft movement from gate to gate and chock to chock through the system. This section summarizes the services, operational concepts, and capabilities associated with surface movement, landing, and departures.

28.1 Airport Operations

Airport operators are involved with many aspects of system performance, including safety, capacity, environmental compatibility, and financial performance. These may be affected by various factors, including the layout of individual airports, the manner in which airspace is organized and used, operating procedures, and the application of technology.

The primary goal is to maintain the high level of safety. This involves providing pilots with information in a convenient and useful manner, maintaining airport facilities to high standards, and providing a safe and secure aircraft operating area.

Runway capacity to accommodate the anticipated number of aircraft operations is a concern at major metropolitan airports where passenger and cargo traffic are concentrated. Inadequate runway capacity results in air traffic delays, additional expense for airlines, inconvenience for passengers, and an increased workload for the FAA air traffic control system. Experience shows that delay gradually increases as air traffic levels rise, until the practical capacity of an airport is reached, after which the average delay per aircraft operation is from 4 to 6 minutes. After this, delays increase rapidly.

An airport is considered to be severely congested when average delay exceeds 9 minutes per operation. Beyond this point, delays become volatile, and a small increase in traffic, adverse weather conditions, or other factors can result in lengthy delays that disrupt flight schedules and impose a heavy workload on the air traffic control system. Adverse weather has a substantial impact on airport capacity, especially at major hubs. The 1997 Aviation Capacity Enhancement Plan indicates that from 1992 through 1996, adverse weather was a major factor affecting NAS capacity, accounting for 72 percent of system delays greater than 15 minutes. Seven airports with an average delay in excess of 9 minutes per operation accounted for most of the severe air traffic delays in the United States in 1996.

The FAA estimates that, if demand were to increase as expected, no new runways were added to major airports, and no advances were made in air traffic control, 15 major airports would be severely congested by 2006. Capacity enhancements are expected as a result of planned new runway construction at certain airports and also from the improvements in air traffic control, such as the passive Final Approach Spacing Tool (pFAST), a new air traffic control (ATC) spacing and sequencing tool that promotes a more efficient flow of air traffic (see Section 23, Terminal). For example, the Dallas-Fort Worth Airport has successfully blended airport capacity planning and the use of pFAST to significantly increase the airport acceptance rate. The effects of these improvements will vary from airport to airport, and site-specific analyses are needed to provide a reliable estimate of the combined effect of all anticipated improvements. The FAA intends to undertake such analyses in partnership with airport operators and users to better understand the future balance between demand and capacity at major airports.

To mitigate the effects of adverse weather on airport capacity, the FAA is implementing a weather architecture in the near term, featuring systems that will be integrated into the overall NAS architecture. One of those systems, the integrated terminal weather system (ITWS) will provide dedicated, enhanced weather support to 45 of the nations's busiest airports. ITWS will receive a myriad of weather data from radars, ground-observing systems, airborne observations, and computer model output. ITWS will then process these data and provide tailored products, such as short-range forecasts of airport-impacting weather to aid traffic supervisors and controllers in optimizing runway usage during storm passage. See Section 26, Aviation Weather, for more details.

Environmental considerations are critical in optimizing airfield capacity. Noise concerns have been a major obstacle to new runway construction and have limited the use of existing runways at some airports. Future enhancements of runway capacity must be compatible with surrounding land uses. Engine emissions are also a concern. The FAA is currently investing in improvements and new technologies for the NAS that will ease ATC restrictions. There are positive environmental and economic benefits to be realized with the planned improvements in capabilities. The estimated savings in fuel used and the reduced emissions are considerable.

Airports are typically owned and operated by local government, and are supported by charges, taxes, and fees paid by airport users. Every effort is made to provide services in a cost-effective manner.

Airports have a complex interrelationship with other NAS components, and good communications among FAA, state, and local officials are essential for NAS modernization to enhance the performance of the airport system.

28.1.1 Surface Movement Guidance and Control Goals

Like the rest of the architecture, airport surface movement begins with goals and operational concepts. The All Weather Operations Panel of the International Civil Aviation Organization (ICAO) has established high-level goals that have become the basis for considering which capabilities are required and may be useful in developing improvements for surface movement operations.[1] The following subset of those goals are applicable to the NAS architecture:

- Pilots, controllers, and vehicle operators should continue to have clearly defined roles and responsibilities that eliminate procedural ambiguities—which may lead to operational errors and deviations.
- Improved means of providing situational awareness should be developed for pilots, controllers, and vehicle operators, considering visibility conditions, traffic density, and airport complexity.
- Improved means of surveillance should be in place (beyond primary radar).
- Delays in ground movements should be reduced, and growth in operations should be accommodated without increases in delays on the ground.
- Surface movement functions should be able to accommodate all aircraft classes and necessary ground vehicles.
- Improved guidance and procedures should be in place to allow:
  - – Safe operations on the airport surface, considering visibility conditions, traffic density, and airport layout
  - – Pilots and vehicle operators to follow their assigned routes in a continuous, unambiguous, and reliable way.
- Airport visual aids that provide guidance for surface movement should be integrated with the surface movement system.
- Air traffic management automation should provide linkages between surface and terminal to produce a seamless, time-based operation with reduced controller and pilot workload.
- Surface movement guidance and control improvements should be developed in a modular form and accommodate all airport types.
- Conflict prediction/detection, analysis, and resolution should be provided.

28.1.2 Surface Operations Characteristics

In addition to the broad goals of ICAO, the Air Traffic Services (ATS) concept of operations (CONOPS) also covers characteristics for surface movement operations and services.[2] The following operating characteristics are consistent with the architecture:

- Improve information exchange and coordination activities, including the expansion of data link capabilities, to more users at more airports.

1. *All Weather Operations Panel Working Paper (AWOP/WP756)*, Sixteenth Meeting, Montreal, June 23 to July 4, 1997.
2. *A Concept of Operations for the National Airspace System in 2005, Air Traffic Services*, September 1997.

- Use automation to enhance the dynamic planning of surface movement, balance taxiway demand, and improve the sequencing of aircraft to the departure threshold.
- Integrate surface and terminal automation so that the most appropriate runway and taxi route can be utilized for the assigned gate. Current and projected areas of congestion on the surface, runway loading, and environmental aspects such as noise balancing will be considered.
- Share information between users and service providers to create a more realistic picture of airport departure and arrival demand.
- Use automation to improve the identification and predicted movement of all aircraft and vehicles on the airport movement area and provide conflict advisories.
- Enhance safety and efficiency by planning an aircraft's movement so that a flight can proceed from deicing to takeoff without stopping.

Airport surface movement guidance and control systems will be used by aircraft and airport vehicles during low-visibility conditions. In addition, drivers' enhanced vision systems will allow better aircraft rescue and firefighting and other airport vehicle operations in low-visibility conditions. The enhanced vision systems will include forward-looking infrared cameras and monitors in vehicles.

28.1.3 Airport Security

Security at major airports is provided through interrelated security measures and resources involving the FAA, airport operators, air carriers, and passengers.

The FAA is responsible for identifying and analyzing threats to security, prescribing security requirements, coordinating security operations, enforcing regulations, and directing law enforcement activities under the governing statutes and regulations.

Airport operators are responsible for providing a secure operating environment for the air carriers and other airport users by ensuring that responsive security programs and emergency action plans are maintained, air operations areas (AOAs) are restricted and protected, law enforcement support is provided to respond to various security threats, and physical security measures for the airport are provided.

Air carriers are responsible for screening passengers with metal detectors, as well as x-raying and inspecting their carry-on articles, securing baggage and cargo areas, protecting the aircraft, and maintaining responsive security programs. Air carriers generally use contractors to perform these functions but are held accountable by the FAA for the effectiveness of the screening operation.

Federal regulations set forth specific requirements for airport security programs, physical security and access control, and law enforcement support. Access control is required for perimeter, terminal, and ramp security areas. Airport perimeter access control usually includes signs announcing restricted areas, a fence barrier around key security areas, fence and perimeter alarm sensors, and lighting of important areas.

Terminal buildings present special security problems because of the proximity of public areas to the AOA. The security plan must allow access for authorized personnel while excluding unauthorized individuals from the AOA. Access controls from the terminal concourse to the AOA must be consistent with fire code provisions regarding exits from areas of public assembly.

The state of the art in airport security is expected to improve over time through accumulated experience and the application of new technology. Changes in security practices and requirements must be thoroughly coordinated with all affected parties, particularly airport operators, because of their potential impact on the cost and efficiency of airport facilities.

28.1.4 Airports Without Air Traffic Control Towers

The United States has 5,200 public-use airports—only 419 of them have airport traffic control towers (ATCTs). Air traffic controllers in the tower provide separation between aircraft and vehicles on the surface and between aircraft in the traffic pattern. At airports without towers, the separation is conducted by the pilots themselves. However, the architecture does include significant improvements, such as the Wide Area Augmentation System (WAAS) for improved navigation and instrument approaches, to assist pilots who use these airports. Towers will be built at new airports and airports experiencing significant growth that meet establishment criteria contained in Aviation Planning Standard Number 1.

28.1.5 Airports Without Radar Surveillance

Many airports today are not covered by radar surveillance. At these airports, instrument flight rules (IFR) services rely on pilot position reports to ensure separation. This is known as a "one-in and one-out" procedure. An arriving aircraft must confirm landing before another aircraft can be cleared to take off or to start an approach under IFR. This reliance on procedural separation increases air traffic controller workload. Procedural separation is less efficient for the pilots than radar separation.

Use of the one-in and one-out procedure will increase with the introduction of instrument approaches to airports that currently do not have approaches. Many of these airports are below radar coverage. The extension of radar coverage is not anticipated in the NAS architecture. The real promise for improved separation services rests with automatic dependent surveillance broadcast (ADS-B) as a basis for automatic dependent surveillance (ADS). Aircraft equipped with ADS-B and cockpit display of traffic information (CDTI) could be cleared for approaches and departures based on either self-separation or by air traffic control facilities that receive ADS-B reports from a nearby ADS ground station. The degree to which the one-in/one-out procedure can be eliminated will depend upon aircraft equipage with ADS-B avionics and installation of ADS ground stations in areas where there is no radar surveillance. Additional details on ADS may be found in Section 16, Surveillance.

28.1.6 Satellite-Based Navigation

The Global Positioning System (GPS) and its Wide Area and Local Area Augmentation Systems (WAAS and LAAS) will provide navigation guidance for all phases of flight, including surface movement. For most airports, approaches will be based on WAAS. For those requiring the equivalent of Category (CAT) II and III approaches, LAAS will be used. LAAS will also be installed at locations where, because of mountainous terrain or high latitudes, WAAS coverage is inadequate. See Section 15, Navigation, Landing, and Lighting Systems, for a further description of the navigation architecture.

28.1.6.1 Instrument Approaches

The FAA intends to develop thousands of new GPS-based approaches, including approximately 200 approaches to heliports. These approaches are currently under development at a planned rate of 500 approaches per year. GPS-based approaches provide both course and vertical guidance. Instrument approaches with vertical guidance were expensive to provide in the past, requiring the installation of specialized, ground-based, electronic approach aids, typically an instrument landing system (ILS) or microwave landing system (MLS) for each runway end. They also required extensive amounts of unobstructed airspace.

The cost and difficulty of providing approaches with vertical guidance limited them to very busy runways, particularly those serving scheduled commercial airlines. This paradigm will shift to a concept wherein satellite-based instrument approaches will serve many runways, with approach minima being determined by such factors as terrain, obstructions, missed approach path, airport geometry, and airport and approach lighting.

For example, if a general aviation airport were seeking a new approach for a runway, a WAAS precision approach might be established to provide minima of 400 feet and 1-mile visibility. This would be adequate for most general aviation users and would not require as extensive approach lights, runway lighting upgrades, or other capital improvements as are associated with a CAT I ILS with minima of 200 feet and ½-mile visibility.

If that same runway had obstructions in the approach that could not be removed by the airport operator, the minima would be adjusted upward. GPS precision approach minima need not be equivalent to CAT I ILS minima, even though GPS with WAAS will support approaches to 200 feet and ½-mile visibility. An airport that already has a CAT I ILS would receive a GPS/WAAS approach to the same runway with the same minima that exist today. When the ILS is decommissioned, the approach capability would continue, only it would be satellite-based.

Approaches to less than 200 feet and ½-mile visibility will require local area augmentation from LAAS, which provides the accuracy, availability, and integrity necessary to support lower minima. One LAAS can accommodate all runways on the airport and is significantly simpler to install, operate, and maintain than the multiple ILSs that were needed for an equivalent capability.

GPS/LAAS is currently planned for 143 locations, ultimately replacing CAT II/III ILS systems, supporting runway upgrades from CAT I ILS to CAT II/III GPS, providing differential correction for airports where terrain or limited WAAS coverage affects performance, and augmenting ADS-B surface surveillance. Additional locations may benefit from LAAS, but airport development would be necessary to realize these opportunities.

Airport managers need to know which ground-based systems will be used to back up GPS during the transition period and thereafter. The FAA is considering a variety of options and intends to select preferred scenarios at the earliest possible date. That information will be shared as it becomes available with airport operators and state aviation agencies to help support their planning activities. The FAA will budget for transition costs related to the facilities, equipment, and services that it has provided historically.

28.1.6.2 Precision-Missed Approach Navigation

WAAS or LAAS can also provide precision-missed approach navigation, resulting in lower approach minima for those airports that have difficult terrain or obstacle clearance situations. A precision-missed approach provides course and vertical guidance. Increased precision on missed approach is tied to a concept called required navigation performance, which would change the criteria by which procedures are to be developed. The FAA is evaluating changes in terminal procedure criteria to take advantage of satellite-based efficiencies in airspace use.

28.1.6.3 Precision Departures

This capability would replace or overlay current standard instrument departures. The advantage to the airport operator is increased precision on ground tracks and the possible benefits in managing airport noise.

28.1.6.4 Nonprecision Approaches

Less precise approaches are adequate to meet the needs of some users. Avionics cost will be lower, since the avionics will not require differential correction. At every runway end with a precision approach, there will also be a published, nonprecision approach with higher minima. This redundancy is important since the nonprecision approach acts to back up the precision approach.

28.1.7 Phasing Down Ground-Based Instrument Approach Aids

The FAA expects augmented GPS will eventually meet all instrument approach needs. However, an assessment of actual satellite-based navigation performance will be made after the fielding of WAAS and certification of approach procedures. Therefore, the FAA intends to phase down ground-based navigational and approach aids (Navaids) as discussed in Section 15, Navigation, Landing, and Lighting Systems.

Decisions on the decommissioning of any ground-based Navaids will take into consideration the availability of a replacement satellite-based navigation procedure, and there will be an overlapping period of coverage at each location to allow for avionics equipage. Phase-down of airport Navaids (excluding visual aids) is expected to begin as soon as practical. The FAA intends to recover and reassign the associated radio frequency spectrum.

The FAA is initiating a study to determine how many Navaids should remain in service to provide a redundant navigational capability. The participation of airport operators and users in the study is planned. The following key service issues are to be studied:

- Developing a phase-down schedule of Navaids beginning in 2005 matched to user equipage with GPS-compatible avionics
- Identifying sufficient ground-based Navaids to support IFR navigation throughout the transition to satellite-based navigation
- Identifying which Navaids will be required to support IFR operations at key airports for general aviation, scheduled air carrier, and

commuter service operations, and along principal air routes following the transition to satellite-based navigation.

28.1.8 Surface Surveillance

Today, airport surface surveillance is provided visually by pilots, controllers, and vehicle operators. At larger airports, visual surveillance is augmented by airport surface detection equipment (ASDE-3). Due to the high cost, equipping additional airports with the ASDE-3 radar would not be feasible; however, a new program for a lower cost surface movement detection system paired with a conflict prediction capability has been approved and potential applications are being evaluated.

The airport movement area safety system (AMASS), which tracks targets, applies safety logic, and alerts tower controllers to potential surface movement conflicts, is being deployed to ASDE-3-equipped airports. This AMASS function has also been demonstrated using ADS-B. Section 16, Surveillance, contains additional details about the surveillance architecture.

28.1.8.1 ADS-B

ADS-B avionics broadcast aircraft position, speed (as derived from GPS), and other useful information (e.g., altitude, intent, aircraft identification) at regular intervals to other aircraft and ground stations. Depending on developments in the Safe Flight 21 Program, use of ADS-B for air-to-air surveillance (i.e., cockpit situational awareness) will begin in Phase 2 of the architecture. Use of ADS as a basis for airport surface surveillance is slated to begin around 2006; its use as a means of surface surveillance has been demonstrated by the FAA and the National Aeronautics and Space Administration (NASA).

Ground vehicles can be equipped with ADS-B for surface surveillance and vehicle management. Benefits such as more efficient aircraft servicing, snow removal, and airport maintenance will encourage airports to equip vehicles. As long as the message broadcasts from the vehicle and aircraft are compatible, ATC and airport surveillance capabilities can be merged.

Ground vehicle equipage costs are likely to be lower than the costs for aircraft equipage. Likewise, cheaper communications links would be possible for systems used to track ground vehicles only. Some vehicles would need to transmit position only, while others, such as operations and firefighting vehicles, would need to have targets displayed to the vehicle operator.

28.1.8.2 Cockpit Moving Maps

By combining GPS aircraft position data with an electronic map of the airport, the pilot can see the aircraft's location on a cockpit display. Adding ADS-B position reports from other aircraft and vehicles to that same display will present a complete surface traffic depiction, which could facilitate operations in limited visibility. Both NASA and the FAA have demonstrated the capability to transmit ATC traffic information via data link to cockpit displays. The advantages to airports might include reduced need for pavement fillets based on more accurate surface navigation by large aircraft and reduced reliance on lighting and signage in extremely low-visibility operations.

28.1.9 Information Sharing and Collaboration

To improve capacity and reduce delay, the architecture provides for information sharing and collaboration between users and service providers. Airports will be able to receive information through the services described in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing. This includes the flight objects, which contain the status of all aircraft flying into and from the airport. This information can be used for flight information systems within the airport terminal and for scheduling maintenance and snow removal operations. Airport systems will be able to communicate with FAA systems through appropriate information security protocols.

28.1.10 Coordination of Plans

It is essential to coordinate the NAS architecture with airport operators and state aviation agencies in order to achieve the potential airport-related benefits. The NAS architecture provides information about changes in how and when services will be provided. Locally prepared airport master and layout plans provide details about future activity at specific airports and the development that will be needed to accommodate it. Together, these documents will assist in planning capital investments, addressing future noise and emissions strategies, and identifying opportunities to provide additional services to airport users

28.2 Airport Development

Airport development—especially construction of new runways, runway extensions, and major terminal expansions—can affect the local FAA workforce, facilities and equipment (F&E) funding, and operations appropriations. Typical impacts include the need for new Navaids; construction of new towers and their necessary equipment; and relocation of existing Navaids, underground communications and power cables, radar units, weather sensors, and other miscellaneous equipment. Depending on the circumstances, the cost of this work may be shared between FAA and airport operators, with some costs paid for by airport operators through reimbursable agreements.

Changes in the NAS can result in new requirements for airport development. For example, establishing a WAAS instrument approach for a runway that does not already have an approach for comparable minimum weather conditions may generate projects to upgrade runway marking and lighting and remove obstructions. Very large investments may be needed to acquire land, relocate parallel taxiways, and otherwise bring airfields up to the standards for low-visibility operations. Airport operators will need to decide whether or not to accept the approaches.

Needed airport development that is significant to national transportation is included in the National Plan of Integrated Airport Systems (NPIAS), a biennial report to Congress by the Secretary of Transportation. Airfield capacity is the largest development category in NPIAS, accounting for 23 percent of development costs. The NPIAS contains 3,294 existing airports, but development is concentrated at the busiest airports, with 44 percent at the 29 large hub airports that each accounts for at least 1 percent of the nation's total passenger enplanements. The airfield capacity development included in the NPIAS will help alleviate congestion at many busy airports. However, certain large metropolitan areas, such as New York, will still have severe problems, and the FAA will continue to focus on the need for additional capacity at those locations.

FAA initiatives to enhance capacity are described in the Aviation Capacity Enhancement Plan. Published annually, the Aviation Capacity Enhancement Plan focuses on the top 100 airports by enplanements. It addresses the application of new procedures, technology, and airspace development to supplement and enhance airfield construction.

28.3 Airport Funding

Airport capital improvements are funded from a variety of sources. Through the F&E program, the FAA pays for most navigation and approach aids and air traffic control facilities. Other airport improvements on the airfield and in the terminal area are undertaken and financed by the airport operator, usually a state or local agency. Local funds, particularly from airport revenues and the issuance of bonds that are backed by future airport revenues, are supplemented by the Airport Improvement Program (AIP) and Passenger Facility Charge (PFC) Program.

The AIP is a federal grant-in-aid program that accounts for about 25 percent of airport capital investments. The 3,294 airports in the NPIAS are eligible to receive AIP funds, and more than 1,000 grants are issued annually.

The AIP is distributed largely in accordance with FAA priorities, and the program focuses on airfield improvements, especially those that are safety-related. The AIP is particularly important to thousands of lower-activity airports that use all of their revenues for operations and maintenance and have little ability to undertake development without financial assistance. There may be a significant future requirement for AIP grants to assist improvements—such as paving, lighting, grading, land acquisition, and obstruction removal—needed by airports to obtain additional instrument approach capability and other potential benefits of the improved NAS.

The PFC is a locally imposed charge by air carriers for each enplaned passenger. PFCs account for about $1 billion annually and are particularly important at busy airports where there are large numbers of enplanements. The FAA must authorize PFC collection and use, but the eligible uses are broad, and the use reflects the airport operator's priority. There is a tendency to use PFCs to improve passenger movement areas, such as terminal buildings and ground access systems.

28.4 Summary

The airport is a key component of the NAS. Airport operators are involved in many aspects of system performance, including safety, capacity, and environmental capability. The FAA will continue to work with airport operators to maximize the effectiveness of NAS modernization initiatives.

28.5 Watch Items

- AIP funding level and stability in funding. The AIP program helps large and small airports expand to meet aviation needs. At the current rate of aviation growth, new runways will be needed. New airports at major urban locations may also be needed between now and 2015.
- Airport development and FAA capital development need to be closely linked so that airport operators and local FAA offices can plan delivery of new capabilities more effectively.

29 FACILITIES AND ASSOCIATED SYSTEMS

This section discusses three major FAA concerns: (1) maintaining existing facilities, (2) replacing and expanding facilities, and (3) new facilities. Also discussed are human factors, risk-mitigation activities, physical security, and costs related to these concerns.

“Facilities” are defined as driveways, roads, grounds, and staffed or unstaffed buildings that are owned, leased, or maintained by the FAA. The term “building” applies to an individual structure and to any enclosed, attached supporting utility systems such as electrical power conditioning and distribution systems and heating, ventilation, and air conditioning (HVAC) equipment.

Facilities must meet requirements mandated by public law and Executive order for facility accessibility and structural and nonstructural seismic reinforcement of occupied federal buildings. Newly constructed facilities and retrofits for existing structures are designed to meet these requirements. Security risk-reduction measures such as fences, guardhouses, and access control systems—when determined to be necessary—are considered as part of a separate security risk-management system for the building or facility. Additional requirements exist to upgrade the facilities to accommodate security risk-management measures. Physical security costs are covered in Section 31, Mission Support.

The FAA maintains and improves buildings and structures that house NAS equipment and personnel (see Table 29-1). Several key facilities are near the end of their forecasted structural economic life.

Refurbishing or replacing these facilities will sustain their existing capability. In cases where facilities are leased, landlords are responsible for some maintenance. However, the FAA maintains these facilities to the extent agreed upon in the leasing agreement.

Table 29-1. Average Age of Key NAS Facilities

Facility Type	Number	Average Age (Years)
ATCT (Towers)	419	26
ARTCC (Centers)	20	40
TRACONs (Terminals)	171	22

Based on their average age, most air traffic control (ATC) facilities will need to be substantially refurbished or replaced between 2001 and 2015. The NAS architecture accounts for this needed effort, and specific details will be developed over the next few years.

The requirements for facility upgrades caused by adding or modifying installed equipment will be defined by the acquisition program providing the new equipment or modification. These requirements include space, quality and quantity of power, and HVAC. A concurrent determination by the responsible line of business (LOB) and the acquisition program will be made concerning the impact of equipment addition or modification on the need for additional security risk-reduction measures at the facility.

29.1 Air Route Traffic Control Centers

The air route traffic control centers (ARTCCs) and the national network control centers (NNCCs) will get structural repairs, external repairs, and internal remodeling. Old water and sewer lines will be replaced. New or refurbished backup power equipment, power conditioning equipment, and batteries will be provided.

In addition, the FAA will make child care facilities available to employees at each of its ARTCCs. These facilities will be completed within the next few years.

29.2 Terminal Facilities

NAS terminal facilities include airport traffic control tower (ATCT) and terminal radar approach control (TRACON) installations. TRACONs include a category of large TRACONs, which consolidate the terminal control responsibilities formerly managed by two or more TRACON facilities. A current example is the proposed Potomac TRACON that will control airspace presently under the jurisdiction of Dulles, Baltimore-Washington, and Ronald Reagan Washington National Airports, along with Andrews Air Force Base—all located in the Washington, D.C., metropolitan area.

Table 29-2. New TRACON Consolidations

Large TRACON	Consolidated TRACONs
Denver	Colorado Springs Pueblo Grand Junction
Atlanta	Atlanta Macon Columbus
Potomac	Dulles National Baltimore Andrews AFB
Northern California	Oakland Sacramento Stockton Monterey Selected Oakland Center Sectors
Central Florida	Jacksonville Orlando Tampa Patrick AFB

Source: NAS Transition and Integration, Terminal Facilities Division (ANS-200)

29.2.1 TRACON and Airport Traffic Control Tower Facilities

Standby power and HVAC equipment at all facilities will be replaced over the next 20 years. Site security systems will be upgraded, with special attention given to the physical security at supporting facilities located on remote islands.

Annually, selected ATCT installations and TRACONs are modernized to accommodate additional traffic at airports and to extend their service life. TRACONs/towers are replaced or consolidated with other operations if they have reached the end of their economic life.

Airport cable loop systems are being upgraded or replaced with fiber optic technology. This upgrade provides the facilities with state-of-the-art communications pathways and allows for redundant nodes and pathways for communications, should a cable cut occur.

Airport traffic control towers and TRACON facilities are evaluated for modernization or replacement in accordance with FAA Order 6480.17. Fifty-three facilities are qualified and validated for establishment or replacement, with 18 of these presently under construction and installation of electronics.

Over the next several years, the FAA will build six to eight replacement facilities per year. The Honolulu TRACON will be expanded to house the combined center radar approach control (CERAP) in Hawaii. A TRACON/tower facility will be completed for Austin-Bergstrom International Airport. Several other airports will qualify for federally funded contract ATC facilities.

29.2.2 Large TRACONS

The New York TRACON facility will be expanded or replaced. The five facilities shown in Table 29-2 will consolidate several existing ATC facilities into a single ATC facility. These facility consolidations will support a more efficient design of the airspace in selected U.S. geographic areas. Facility consolidation will improve ATC operations and reduce the total cost of operating multiple smaller facilities.

Airspace actions are subject to environmental assessments and procedures if the area of the proposed facility is less than 3,000 sq. ft. Compliance with the National Environmental Policy Act of 1969 (NEPA) is mandatory for each organization establishing an airspace configuration.

29.3 Flight Service Station Facilities

The installation of the Operational and Supportability Implementation System (OASIS) requires additional space, electrical power capacity, and HVAC at existing automated flight service station (AFSS) locations. In addition, power conditioning and battery backup capabilities will be added at those AFSSs that experience frequent interruptions due to power fluctuations.

29.4 General NAS Facilities

General NAS facilities—numbering well into the thousands—house and support communications, surveillance, and navigational aids. All of these facilities are aging and must be periodically refurbished. This ongoing need is handled by prioritizing the facilities on the basis of their condition, criticality of their function to the NAS mission, and other criteria. The top-priority facilities then receive roofs, paint, siding, or whatever is needed to complete refurbishment and bring the facility up to current standards. Additional requirements exist to upgrade the facilities to accommodate security risk-management measures.

29.5 NAS Support Facilities

Facilities and equipment at the William J. Hughes Technical Center (WJHTC) in Atlantic City, N.J., are failing and need refurbishment. Specifically, chiller and boiler units and electrical substations are scheduled to be refurbished or replaced. Drainage system and fire protection system improvements will be accomplished. Refurbishment of FAA-owned airport runways, taxiways, shoulders, and airport lighting systems is planned.

Plans include new facilities at the Mike Monroney Aeronautical Center (MMAC) to provide areas for training, logistics, engineering, and aeromedical research. New training complexes will provide classrooms, training laboratories, and work areas. New engineering support areas will accommodate support personnel, systems, equipment, and functions for defining and resolving NAS problems, sustaining engineering functions, and related activities. The logistics support area provides space for repair, test, quality control, engineering, and supply support functions. The Civil Aeromedical Institute, general Aeronautical Center operations (e.g., storage, staging, shipping, maintenance, flight line support), and other tenant needs will be accommodated.

29.6 FAA Residences (Employee Housing)

The FAA operates and maintains quarters for employees and their families in remote areas where suitable housing is unavailable. This ongoing effort provides, maintains, and refurbishes residences and other temporary quarters in Alaska, the Caribbean, the Grand Canyon, Nantucket, and the Pacific Territories. The FAA also leases housing units when it is economical.

29.7 Facility Power System Maintenance

Current power systems provide for various levels of reliability for the NAS system, service, or facility to be supported. The level of air traffic activity determines the design of the power system installed. The most critical facilities—ARTCCs and some large TRACONs—have multiple redundant systems, which include at least two separately derived utility power sources, multiple uninterruptable power systems, and excess engine/generator capacity to allow for engine/generator failure.

Newer technology systems have less tolerance for power interruptions than the older equipment. Most new systems, especially commercial-off-the-shelf-based workstations, require several minutes to reboot and reload software when power is interrupted. For some critical air traffic systems and services, this type of interruption is unacceptable. To prevent these occurrences, uninterruptable power systems are provided. The most expensive components are the batteries, which have a service life of 5 to 10 years.

Approximately 3,500 engine/generator units are available for standby power. Most of these engines are over 20 years old and are being replaced on a scheduled basis. The current goal is to maintain an engine/generator inventory that is no more than 15 years old.

Facility power systems, including power control cables and lightning protection, are also considered part of the infrastructure and are currently being upgraded.

29.8 Environmental Concerns

The FAA is subject to a number of environmental statutes and regulations when either establishing or disposing of facilities. These concerns are addressed in Section 30, Environment and Energy.

29.9 Facility Security

The FAA uses thousands of navigation and ATC facilities of all types, sizes, and functions to carry out its responsibilities for efficiently managing and controlling the NAS. Damage to or destruction of any FAA facility has a measurable affect on the NAS—depending on the criticality of the facility and its mission in overall NAS operations. Federal facilities may be vulnerable to potential internal sabotage and external attacks, which could disrupt NAS operations, degrade flying safety, compromise national security, and damage the U.S. economy.

All elements of the FAA's critical infrastructure need physical facility security protection. Critical assets at FAA facilities need to be identified, risks assessed, and the threats and vulnerabilities to those assets reduced or eliminated. Physical security must be addressed in an orderly, logical process that results in cost-effective risk reduction and minimizes operational inconveniences while preserving operational integrity.

As a federal agency, the FAA and its facilities are required to comply with those minimum facility physical security standards identified in the June 1985 Department of Justice (DOJ) report, *Vulnerability Assessment of Federal Facilities*. The FAA is currently conducting facility physical security surveys and assessments to identify critical security risks. These surveys will lead to risk-reduction measures that will ensure each facility meets baseline security standards identified in the DOJ report and FAA Order 1600.6c (FAA Physical Security Management Program).

Plans for new facilities or major modification to existing facilities will be coordinated with the Office of Civil Aviation Security Operations (ACO-400) to ensure appropriate security measures have been included in the design plans. Facilities that are to be occupied by FAA elements must have provisions that enable facility management to:

- Control access into the facility at all times
  - Reduce the number of entrances to the minimum consistent with the operational needs of the facility
  - Locate parking 100 feet from the facility and in one area on the facility site
- Control the removal of and/or the unauthorized access to FAA property, equipment, personnel, and official records
- Obtain protective services and/or public safety response when disorders or other emergency situations arise.

Utility systems vital to the continued operation of the NAS facility will be protected against tampering, vandalism, and sabotage. Where possible, areas containing critical utility systems will not be located adjacent to high-use areas, such as loading docks, visitor entrances, parking areas, etc. Where key utilities must be located outside the main structure, whenever possible they will not be located within 100 feet of the perimeter fence, boundary, or parking areas. Such utilities would include:

- Telephone and electrical closets
- Power supply equipment to include emergency power equipment
- Power conditioning equipment and rooms
- Environmental control systems
- Air conditioning rooms and equipment.

The design of a NAS facility should emphasize the internal and external configuration of the facility and the proper placement of assets or resources having security considerations. The correct location of a facility function can often serve as an effective safeguard and deterrent against unauthorized entry, theft, or sabotage.

Electronic card access systems, intrusion detection alarms, and closed-circuit television are increasingly used in FAA facilities. Close coordination with ACO-400 and the responsible civil aviation security regional office will ensure human resources, equipment hardware, and software are fully integrated for the protection of personnel, facilities, and assets. FAA regional civil aviation security offices will conduct security surveys of new or renovated existing facilities to determine and establish baseline security risk-reduction measures that will ensure that each facility meets the minimum federal physical security standards identified in FAA Order 1600.6c and the DOJ report.

29.10 Human Factors

Providing the proper facilities and environment for the people and equipment that support the NAS requires application of human factors engineering during the acquisition of FAA facilities (whether new, modified, or consolidated). This approach is similar to the way human performance considerations are incorporated into other FAA acquisitions for systems and services.

Human-workspace interfaces, human operational requirements, and associated safety considerations within the facilities are the basis for including human factors engineering during the planning (buy, lease, or build), alternative analysis, design, testing, and acceptance of facilities. Human factors engineering focuses on identifying and resolving human engineering and ergonomic issues related to operational requirements, workspace and equipment layout, team communication, organizational design, and personnel health, comfort, and occupational safety.

This approach reduces long-term costs (through efficient design and use of personnel resources, skills, training, and procedures for the facility),

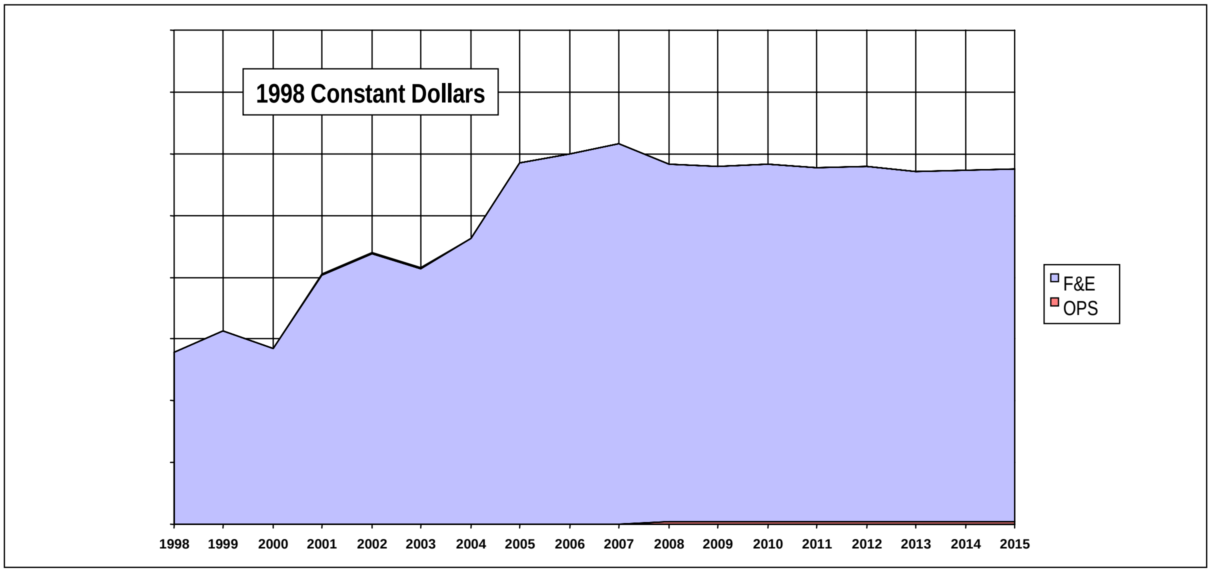

Figure 29-1. Estimated Facilities Costs

minimizes the need for facilities modification (through improved compatibility and suitability with the operational and maintenance concepts), and enhances the performance of NAS operations and maintenance.

29.11 Costs

The FAA estimates for facilities and equipment (F&E) and operations (OPS) life-cycle costs for facilities and associated equipment architecture from 1998 through 2015 are presented in Figure 29-1. OPS costs are for computer aided engineering graphics (CAEG) system maintenance.

29.12 Summary

The FAA must continue to maintain its facilities and associated systems. The key facilities in the NAS are aging and supportability of the facilities is a critical need that the FAA can no longer defer.

30 ENVIRONMENT AND ENERGY

30.1 NAS Modernization Impact

NAS modernization will produce a series of expected environmental benefits, including fuel conservation, fewer FAA facilities, and more energy-efficient new facilities.

Air travel fuel conservation will reduce emissions of greenhouse gases and other pollutants. Estimates of reductions for the years through 2015 were developed for a projected fleet mix and projected traffic increases by phase of flight (e.g., en route) in the continental United States. Results indicate potential annual savings of over 10 billion pounds of fuel, over 200 million pounds of both nitrogen dioxide and carbon monoxide, and 60 million pounds of hydrocarbons, as compared to what would be used without NAS modernization.

The Global Positioning System (GPS) is expected to require fewer land-based navigation facilities. Thus, this land may be available for other uses, and less use of environmentally sensitive lands is expected. New facilities and equipment will generally be more energy-efficient, which will reduce FAA operating costs and emissions of greenhouse gases and other pollutants from these facilities.

Contaminated sites will be cleaned up during the decommissioning and disposal process. While some real property, equipment, and supplies may be preserved by the FAA or other organizations, much will be recycled or used for non-FAA purposes. With fewer land-based facilities, community controversy over aesthetics and electromagnetic fields may be avoided.

The NAS architecture demonstrates the FAA's leadership in meeting federal goals for sustainable development. Sustainable development is defined as "meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs."[1]

The United States committed itself to sustainable development at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro and in the 1996 President's Council on Sustainable Development report, *Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future.* One of the key principles of sustainable development is that a healthy economy depends on healthy communities and a healthy environment for all. Through the NAS architecture, the FAA will foster safety in aviation, in tandem with federal goals for national security, economic growth, environmental health, and community needs.

The FAA has developed and is implementing specific mandated programs in the areas of environmental compliance, occupational safety and health compliance, and energy conservation. These programs apply to acquisition of new equipment and facilities and disposal of existing equipment and facilities.

In the decisionmaking process for siting, operating, and disposing of new FAA facilities, the FAA is required to consider the effects of proposed actions on the human environment by the National Environmental Policy Act of 1969 (NEPA) and the Council on Environmental Quality (CEQ). The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences and take actions that protect, restore, and enhance the environment.

Although the primary consideration in modernizing the NAS is aviation safety, the NAS—to be acceptable to the public—must and will address other public concerns related to human health, welfare, and safety. These concerns about impacts on the human environment (both positive and negative) include noise changes, community disruption, relocation, surface and air traffic changes, changes to sensitive cultural and natural resources (e.g., preservation of wildlife refuges, National Parks, and bird sanctuaries), air and water quality, water and sewer demand, energy demand, aesthetics, site cleanup, and concerns about electromagnetic fields.

30.2 Environmental Compliance and Cleanup Program

The FAA recognizes the need to comply with all federal, state, and local environmental require-

1. *Our Common Future, 1987* (Brundtland Report), United Nations World Commission for Environment and Development, 1987.

ments. The agency has moved forward with implementing the Hazardous Materials (HazMat) Management/Environmental Cleanup Program to systematically identify, evaluate, and remediate environmentally contaminated sites in the NAS (including site characterization, remediation plans/designs, cleanup activities, and monitoring). Programs include, but are not limited to, the fuel storage tanks, recycling and waste minimization, hazardous waste disposal, contamination assessment and cleanup, and polychlorinated biphenyl (PCB) programs.

30.3 Occupational Safety and Health Program

The mission of the Occupational Safety and Health (OS&H) program is to provide for the occupational safety and health of employees, prevent accidental loss of material resources, avoid facility interruptions due to accident or fire, and enforce a system of formal accountability. This is accomplished through regulatory compliance and program management principles. The program provides the comprehensive, agencywide occupational safety and health actions/activities (including fire life safety) necessary to ensure FAA compliance with federal mandates and negotiated agreements to integrate a philosophy regarding these areas of effort into the FAA culture and to promote a safe and healthful workplace.

This effort starts in the design phase of a system or project, thereby reducing the probability of retrofit or noncompliance, and continues throughout the entire life cycle. Significant parts of the programs are field-oriented and administered at the regional level. Some examples of mandated programs are the Lockout/Tagout, Fire Protection, Fire/Life Safety, Confined Space, Fall Protection, Hearing Conservation, Personnel Protective Equipment, Compressed Gas Safety, Hazard Communication, Training, Walking/Working Surfaces, and Housekeeping programs.

30.4 Energy Conservation

The Federal Energy Act and Executive Order 12902 require the FAA to reduce facility energy consumption to 1985 levels. Recent federal legislation also requires all federal agencies to use life-cycle costing analysis when procuring new systems in order to enhance the transition of new and efficient technologies into the workplace. The FAA program will integrate “best available technologies” into acquisitions to improve system operability while reducing energy consumption. By monitoring utility resource expenditure savings, the FAA will be able to retain and reinvest the savings in the energy program’s future.

30.5 Property Transfer Environmental Liability

As in the private sector, federal agencies may be held liable for cleanup of site contamination as an owner or operator of a site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). As a result, evaluating candidate properties for potential environmental contamination and liability has become one of the essential steps in real property transactions. Known in the FAA as the Environmental Due Diligence Audit (EDDA), this evaluation process applies whether acquiring, leasing, transferring, or terminating agency interest in real property. As the NAS architecture is realized, real property transactions—terminations or disposals of property in particular—will increase. To avoid long-term liability and ensure compliance with CERCLA and the Community Environmental Response Facilitation Act (CERFA), the FAA must conduct EDDAs, document hazardous waste activities, and clean up any contamination on real property transferred out of the Federal Government.

30.6 Research, Engineering, and Development

Protecting the environment poses the greatest single challenge to continued growth and prosperity of the aviation system. The FAA is committed to environmental stewardship of all programs, systems, and facilities in order to identify and correct environmental problems before they pose a threat to public welfare, employees, or the quality of the environment. Through an optimal mix of aircraft and engine certification standards, operational procedures, compatible land use, and abatement technology, the agency intends to reduce the impact of aircraft noise.

This will also minimize the impact of aircraft emissions and assist airports in applying practicable measures to avoid or minimize adverse impacts on air, soil, and water quality. The FAA’s Plan for Research, Engineering and Development details the programs selected to ensure continued safety, security, capacity, efficiency, and an environmentally sound aviation system. The R,E&D Plan should be consulted for detailed information in this area.

The FAA and the National Aeronautics and Space Administration (NASA) have been working together on this issue. In 1995, the FAA and NASA administrators signed a memorandum of understanding (MOU) on airspace system users operational flexibility and productivity.

The MOU establishes an FAA/NASA interagency air traffic management integration product team (IAIPT) responsible for planning, oversight, and management of joint efforts. The principal defining documents for the IAIPT are the *Integrated Plan for ATM Research and Technology Development* and the IAIPT management plan.

30.7 Costs

The FAA's estimates for research, engineering, and development (R,E&D) and facilities and equipment (F&E) for environment and energy life-cycle costs associated with regulatory compliance for 1998 through 2015 are shown in constant FY98 dollars in Figure 30-1. Estimates for operations (OPS) costs are included in Section 31, Mission Support.

30.8 Summary

Modernizing the NAS will have predictable and unpredictable impacts on the environment. Many of the modernization efforts will have the benefit of reducing pollution and gaseous emissions. Replacing the aging NAS infrastructure, however, poses numerous problems in terms of avoiding surface pollution, as well as unknown costs for rehabilitating contaminated sites scheduled for decommissioning or replacement.

The Federal Energy Policy Act and Executive Order 12902 require the FAA to meet certain energy and water conservation goals. The goals are to reduce cost, improve the environment, and minimize the use of petroleum-based fuels in FAA buildings and facilities. The FAA is required, among other things, to reduce energy consumption in FY00 by 20 percent from FY85 levels and in FY05 by 30 percent from FY85 levels.

PART III

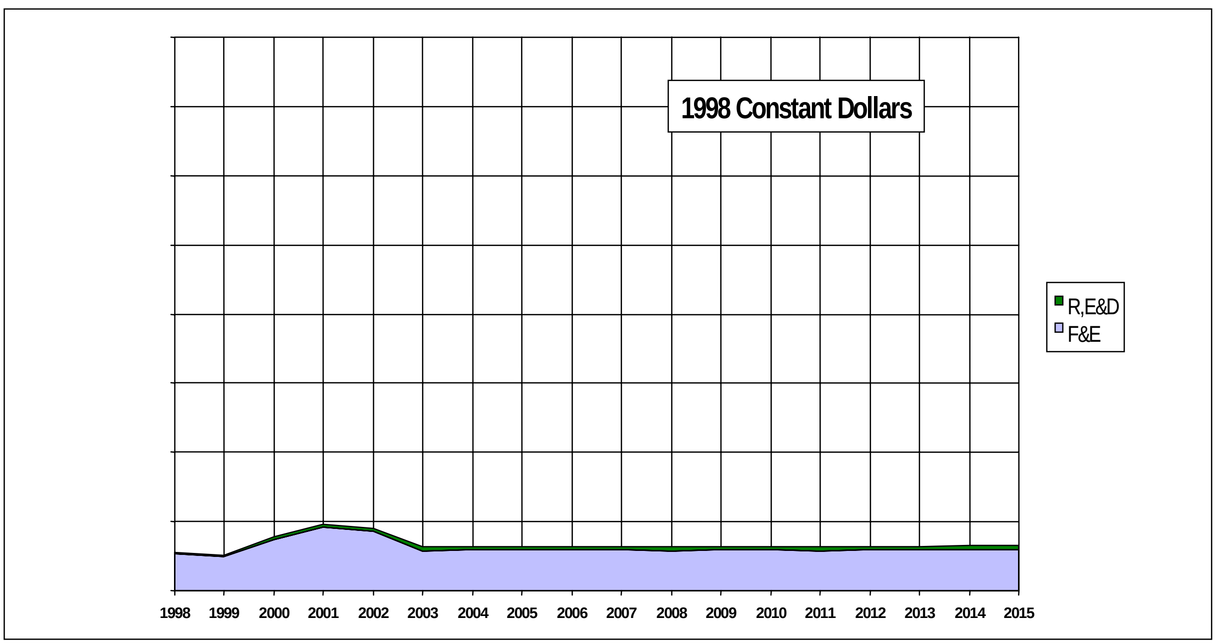

Figure 30-1. Estimated Environment and Energy Costs

31 MISSION SUPPORT

Mission support services assist the agency in delivering primary services and meeting strategic and performance goals cited in the *FAA Strategic Plan.*

For this discussion, mission support services are grouped into three categories: strategic support functions, tactical support functions, and business operations. Strategic support functions support the agency over the long term, whereas tactical support functions are involved with day-to-day agency operations.

Three major assumptions have been made for purposes of this discussion. First, specific hardware, software, or other items needed by a support function (e.g., Logistics Center spare parts) to implement a particular program will be identified, approved, and funded as part of that program through the investment analysis process. Second, all FAA personnel costs to perform the functions identified in this section have been captured in Section 12 and Sections 14 through 27. Third, the final disposition of a support system used in NAS modernization (e.g., one used for testing or training) will be decided during the investment analysis process.

31.1 Strategic Support Functions

Strategic support functions are performed by one or more FAA organizations to support air traffic management or regulation and certification services over the long term.

NAS Integrated Performance Management

The Air Traffic Services (ATS) NAS integrated performance management function develops customer-oriented outcome-based system performance measures and monitors system performance. It also recommends strategies for performance improvement. Performance measures represent operational outcomes desired by NAS users. The outcomes reflect overall performance across all air traffic management services.

Performance measures are developed in conjunction with the user community. Systems initially supporting this function include the Air Traffic Operational Management System (ATOMS), National Airspace Information Monitoring System (NAIMS), the Consolidated Operations and Delay Analysis System (CODAS), and the National Airspace System Performance Analysis System (NASPAS).

Airspace Management

The FAA has custodial management responsibility for airspace. The existing airspace structure was designed around the concept that airspace can be partitioned into volumes that air traffic controllers could monitor and use to maintain separation of aircraft. Increased traffic and changing customer needs have required changes in operations and air traffic management and have highlighted the need for airspace management to evolve and focus on a national perspective. The strategic airspace management function identifies the requirements and plans for airspace changes and also supports their implementation. A key system supporting this function is the airspace analytical tool system (AATS). The system analyzes NAS airspace safety, efficiency, capacity, design, and billing (i.e., user fees). It also assesses environmental issues associated with airspace changes.

Aeronautical Information Service

The Aeronautical Information Service collects, validates, and disseminates aeronautical information. The service provides an up-to-date repository of information about NAS elements (e.g., airports/runways, Navaids, fixes, remote communication outlets, and towers). The aeronautical information is used for publishing charts and documents and as electronic NAS configuration data for airspace analysis, flight service, weather, and other electronic systems. The future architecture of the Aeronautical Information Service is designed for source data entry and online access to current information. The Operational Data Management System (ODMS) is replacing the current closed system architecture.

Air Traffic Operations and Procedures

The FAA needs the capability to monitor and manage its air traffic operations on a continuing basis. It also needs to plan for meeting the demand of current and future forecasted air traffic services. The strategic operations and procedures function supports these activities. This function develops and maintains the FAA's NAS Concept of Operations document used to guide NAS architecture development; assists with requirements validation and with implementing new systems into the NAS; and develops and publishes new air traffic procedures required to support NAS modernization.

NAS Transition, Integration, and Implementation

This function supports the capability to implement and integrate new systems and facilities into the NAS. Types of activities include site selection analysis, site preparation and construction, equipment installation and testing, facility transition plans, system inservice reviews, and other activities. It develops guidelines and policies for transition planning of NAS programs and identifies and coordinates resolution of implementation and transition issues among NAS programs.

This function includes computer-aided engineering and 3-dimensional design tools for facility modeling and site analyses that support transition, installation, and site planning.

System Maintenance Operations

This function provides guidance and tools to monitor NAS systems and manage the operation and maintenance of the systems. It also provides for the planning and management of leased communications.

System Support Operations

This function provides second-level hardware and software engineering support to the NAS field facilities. The function includes documentation control, publication and issuance of directives, and inservice improvements. Strategic operational support activities include planning for second-level engineering support, managing the NAS software life cycle, developing second-level national software engineering policy, providing software support tools and practices, and providing configuration management of inservice hardware and software.

NAS Spectrum Engineering Management

By national policy, the FAA is the manager of all aeronautical spectrum required to support NAS communications, navigation, and surveillance (CNS) systems. This spectrum must be available at all times and be free of radio frequency interference. This function provides support to obtain and protect necessary frequencies for current and future NAS operations. Additionally, the FAA provides both national and international coordination for aeronautical mobile services, aeronautical fixed services, and aeronautical mobile satellite services in developing International Civil Aviation Organization (ICAO) standards and recommended practices.

This function provides spectrum engineering and frequency management support for NAS modernization projects. Furthermore, the function provides the regions with the training, resources, and equipment (i.e., spectrum analyzers and handheld direction finders) required to independently identify the source of interference in a timely manner.

System Requirements, Design, and Acquisition

This function identifies and prioritizes mission needs; baselines system cost, performance, and user benefits; documents requirements; recommends alternative solutions; and supports implementation of selected alternatives. The function provides automated tools, facilities, and processes for research, engineering, and development (R,E&D) management and implementation, mission and investment analysis, system engineering and analysis, software engineering analysis, system development and testing support, program engineering and evaluation, acquisition support, system implementation, and deployment decisions.

This function develops and maintains the NAS architecture. It manages crosscutting NAS information technology programs, such as NAS information standards activities and NAS information security activities. Costs for these activities are covered in Sections 19 and 9 respectively. It also provides R,E&D management, NAS program management, mission and investment analysis, and system engineering.

Operational Testing and Aviation Research

The William J. Hughes Technical Center (WJHTC) provides technical laboratories to support NAS testing and aviation research activities. This function coordinates space requirements, installation plans, and changes to ensure the laboratory meets testing and research needs. Other technical laboratories are used by the FAA, and the costs for these laboratories are captured under each individual application.

This function provides unique nonoperational test beds, not available elsewhere, that duplicate the NAS environment. This function also provides support applications, fixed-wing aircraft and helicopters to provide flight data for projects, ATC simulation support, data centers for computational modeling and research data analysis, and human factors support.

Logistics Support

The logistics function is responsible for depot and limited field maintenance; supply support for NAS equipment and agency aircraft; replenishing and repairing spares; and purchasing, leasing, and managing real estate, including land, office space, and specialized facilities. This function identifies the requirements for and funds the acquisition of spare parts and repair services and other logistics-related activities, such as contracted logistics support and logistics training.

Training

The training function, as defined here, supports general FAA training requirements, including those for NAS modernization activities and operations. The FAA Academy at the Mike Monroney Aeronautical Center (MMAC) conducts technical training and maintains high performance standards for air traffic controllers, engineers, inspectors, and other FAA specialists. A portion of the academy is dedicated to training international aviation personnel through the International Training Services Center (ITSC), which promotes seamless transitions by introducing the new technologies being incorporated into the NAS.

Academy classrooms, laboratories, and instructional staff work areas need to be modernized to fulfill the FAA training mission to coincide with new technologies entering the NAS. The training function identifies requirements for and provides the tools and internal infrastructure to deliver technical training courses. This function includes funding for the FAA Academy, contracted training, and computer-based instruction equipment replacement, upgrades, and conversions to reduce overall training costs.

The Center for Management Development supports the agency's continuing efforts to ensure a safer, more efficiently managed NAS. The center's curriculum is broad and designed to strengthen both interpersonal and technical management skills. All courses focus on actual job functions to help build the specific skills needed to improve job performance.

Flight Inspection and Procedures

Flight inspection and procedures functions are performed by Aviation System Standards (AVN) at the MMAC, FAA Headquarters, the Air Traffic Control System Command Center (ATCSCC), and in the regions. The National Flight Procedures Office, located at the MMAC, is the central location for the development and standardization of instrument flight procedures and related technical support functions. The Flight Inspection Operations Division performs flight inspection functions and provides the tools and infrastructure to support in-flight inspection and evaluation of air navigation aids and instrument flight procedures. The FAA's flight inspection aircraft support domestic, foreign, and military worldwide navigational air inspection requirements.

This function procures and leases FAA flight inspection aircraft and provides FAA Academy flight simulators used to train aviation safety inspectors. The function also develops automated systems, including the instrument approach procedures automation (IAPA) system and the aviation standards information system (ASIS). The IAPA system provides automated tools to assist development of timely and accurate standard instrument approach procedures (SIAP).

Regulatory and Certification Activities

This function includes regulatory and certification activities not covered elsewhere. It provides the tools and processes needed to support ATS and other organizations in performing regulatory- and certification-related activities. A key system supporting this function is the obstruction evaluation/airspace and airport analysis (OE/AAA) system.

31.2 Tactical Support Functions

These functions are performed by one or more FAA organizations to support air traffic management and regulation and certification services.

Air Traffic Operations and Procedures

The tactical operations and procedures support function monitors day-to-day NAS operations. It also includes such activities as contingency planning and facility evacuation.

Flight Advisory and Hazardous Information Service

This service provides real-time information affecting flight conditions to pilots by issuing notices to airmen (NOTAMs). NOTAMs are collected, processed, and distributed via the weather message switching center replacement (WMSCR), the Consolidated NOTAM System, the National Airspace Data Interchange Network (NADIN), and other means. The Consolidated NOTAM System will be replaced by ODMS.

System Maintenance and Operations Support

System maintenance and operations (SMO) support provides onsite maintenance and repair services throughout the NAS. These services include site program implementation of new facilities and equipment; first-level technical engineering support for the NAS hardware and software; certification and verification of operational hardware and software; day-to-day technical assistance and coordination for hardware and software users; and certification of services provided to the air traffic environment, automation, communications, and surveillance.

System Support Operations

Tactical support includes developing hardware and software modifications, implementing approved changes, evaluating systems and system changes, and other tasks as required to ensure reliability and maintainability of the NAS. Operational support activities include maintaining operational software for all NAS systems; providing second-level hardware and software engineering support to field facilities; developing and implementing hardware and software enhancements; participating in systems operational test and evaluation and verification; and conducting system shakedown tests.

Logistics Support

This support function provides procurement, real estate, material management, and automated data processing support services to implement capital investment programs in the regions and centers. This function uses contracted support for many of its activities.

Training

The tactical training function provides on-the-job training for controllers and other specialists. This function supports technical training conducted or contracted out at regional or local facilities.

31.3 Business Operations

Business operations functions support the delivery of all FAA services. The following paragraphs provide high-level descriptions of several business operations functions.

Management and Planning

This function includes activities such as conducting special studies, evaluations, and appraisals; developing staffing standards; disseminating information and policy; and supporting the agency in organizational analysis, management studies, and management productivity. It implements the National Performance Review (NPR) Customer Service Initiative, supports strategic and business performance planning efforts, and develops the Government Performance and Results Act (GPRA) Annual Performance Plan.

Safety Data Analysis and Reporting

FAA management needs timely, accurate, and comprehensive information to support safety decisionmaking. The safety data analysis function provides the tools to identify previously hidden indicators of potential safety problems. The NAS Data Analysis Center (NASDAC) facility has been established at FAA Headquarters to support this function. Online services will be provided for FAA personnel and for the public.

Human Resources Management

This function develops plans and programs relating to recruitment; employment; compensation; benefits; performance management; training; human resource planning, evaluation, and development; and labor and employee relations. The function supports all training activities not addressed elsewhere.

Financial Resources Management

The financial resources management function develops plans and programs for accounting, budget, and financial management, including financial management systems. It prepares financial management reports, performs accounting operations, prepares and justifies budgets, sets travel policy, collects user fees, and supports financial reform initiatives. The function, under the guidance of the Chief Financial Officer, implements the agency's Internal Control Review Program and the Federal Integrity Act Program. It also designs and implements the new cost accounting system to study the possible implementation of user fees and meet other new requirements.

Information Resources Management (IRM)

This function plans for and develops corporate information systems and maintains corporate information technology management policy. All FAA organizations participate in this function. It manages crosscutting information technology activities and major information technology service contracts such as the integrated computer environment-mainframe and networking (ICE-MAN). This function also implements the Information Technology Management and Reform Act of 1996 (ITMRA). Major IRM/IT activities include the following:

- *Year 2000 (Y2K) Computer Program.* This activity provides for the renovation of all FAA systems that are currently not Y2K-compliant. Many FAA systems, including its core business systems as well as those that comprise the NAS, have been identified as mission-critical and will be affected by the Y2K problem. All FAA systems must be Y2K-compliant before the arrival of the millennium to ensure continuation of safe, efficient, and reliable air traffic services. FAA systems are undergoing a five-phase Y2K repair process, consisting of awareness, assessment, renovation, validation, and implementation. Through this process, all FAA systems will be certified as Y2K-compliant and implemented by June 30, 1999.

- *Corporate Systems Architecture.* This activity establishes, maintains, and enhances an agencywide systems architecture. It concentrates on three distinct elements: software engineering; technology and architecture; and data management, access, and information technology security.

  – The software engineering element focuses on improving the maturity level of FAA organizations and major system suppliers, developing an information architecture for the current Host system to support Host replacement activities, providing guidelines for using commercial off-the-shelf (COTS/nondevelopmental items (NDI) in ground-based systems, and developing guidelines and procedural changes necessary to streamline the software aspects of certification for avionics and ground-based systems. Also, the FAA will help RTCA Special Committee 190 elaborate guidance on use of DO 178B for ground-based systems and using COTS components. This activity will be supported by multiyear FAA programs to increase knowledge of how to certify COTS software components to DO 178B.

  – The technology and architecture element develops standards and implements an interoperable infrastructure to guide government, industry, and the FAA in purchasing, developing, and certifying software-intensive systems. It will permit applications to run on a variety of hardware platforms and minimize the cost of incorporating new standards in software and hardware.

  – The data management element supports establishment of secure electronic data interchange to ensure access to information, people, and organizations needed for decisionmaking.

- *NAS Management Automation Program (NASMAP).* This activity provides the infrastructure, architecture, and operational capability to structure and provide access to mis-

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sion-critical data for those employees, managers, and executives who need the data for work or decision processes.

Acquisition Management

This function develops and maintains acquisition policy and guidance and implements acquisition reform. It provides contracting and procurement support for agency acquisitions.

Administrative Facilities Management

This function performs activities such as building space management, administrative telecommunications management, property management, utilities management, and other administrative management functions.

31.4 Costs

FAA estimates for R,E&D; operations (OPS); and facilities and equipment (F&E) costs for mission support and regulation and certification services are depicted in constant FY98 dollars in Figure 31-1. It is assumed that leases and projects requiring annual funding will continue indefinitely. Contracts that provide services or technical expertise will be funded as required, and these costs will increase as the level of modernization, defined in the NAS architecture, requires additional R,E&D, acquisition, system engineering, implementation, and regional support. Technology refresh costs are included for information technology systems, and OPS costs are included for fielded information technology systems.

31.5 Summary

The FAA is striving to maintain its capability to provide the best ATC services to its customers. Mission support services enable the agency to meet strategic and performance goals.

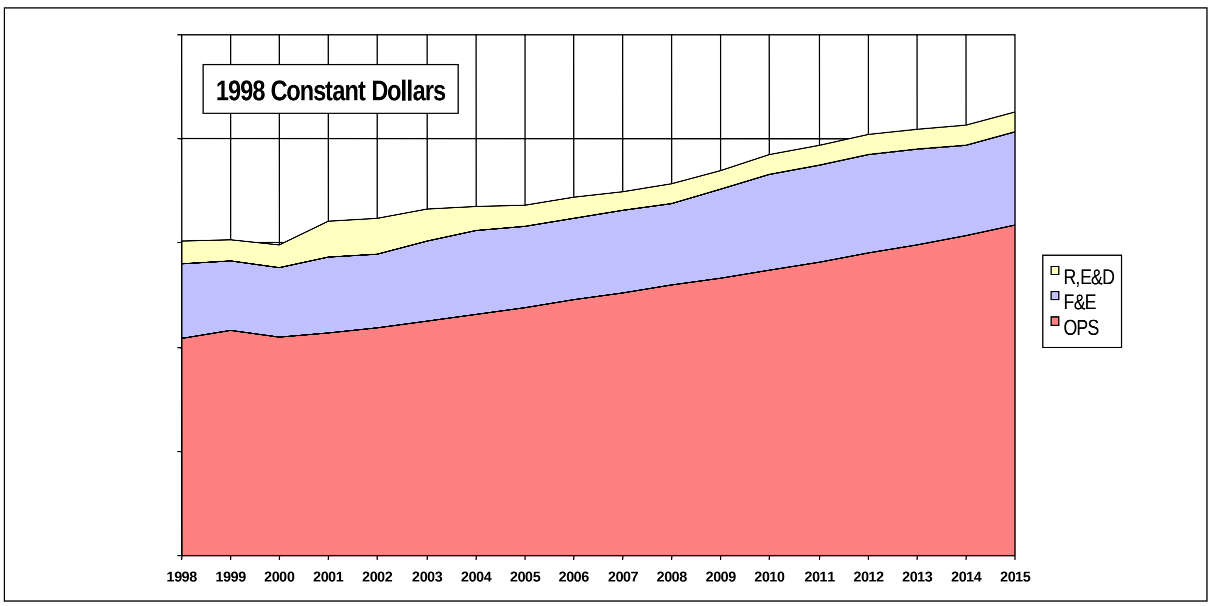

Figure 31-1. Estimated Mission Support Costs

PART IV

NAS ARCHITECTURE SUMMARY

33 NAS ARCHITECTURE SUMMARY

NAS users and the FAA defined the future operations of the NAS in the *Joint Government/Industry Operational Concept for the Evolution of Free Flight.* This concept of operations, which is the foundation of the architecture, is consistent with the FAA's Air Traffic Services (ATS) *A Concept of Operations for the National Airspace System in 2005*.

This architecture is an evolutionary plan for modernizing the NAS and moving towards Free Flight. It incorporates new technologies, procedures, and concepts intended to meet the needs of NAS users and service providers. It includes schedules for the various NAS components, aligned to the expected funding levels indicated by the FAA's in January 1998 funding projections through 2015. The architecture is designed to provide *all* airspace users with more flexible and efficient operations.

The NAS architecture describes changes to the NAS in communications, navigation, surveillance, automation tools, and avionics designed to improve NAS operations and services. Specific details contained in this architecture include:

- Description of NAS capabilities
- Enabling technologies, including their interdependencies
- Research and development required for new technology and procedures
- Transition schedules for functional enhancements
- Projected costs for the FAA and users.

The NAS architecture is divided into three implementation phases, from 1998 to 2015:

- *Phase 1 (1998–2002):* Focuses on sustaining essential air traffic control services and delivering early user benefits; satellite-based navigation systems will be deployed and air-air surveillance will be introduced
- *Phase 2 (2003–2007):* Concentrates on deploying the next generation of communications, navigation, and surveillance (CNS) equipment and the automation upgrades necessary to accommodate new CNS capabilities
- *Phase 3 (2008–2015):* Completes the required infrastructure and integration of automation advancements with the new CNS technologies that enable additional Free Flight capabilities throughout the NAS.

The architecture will continue to be updated, and numerous factors can and will change it. Results of investment analyses will immediately be factored into the NAS Architecture data base and may affect individual program costs. Research continues to identify new technologies that could affect cost and the timing of improvements. Funding levels may have a major impact on both the timing and extent of NAS modernization. Because this architecture takes an integrated view, any individual program slip can affect other programs and eventually lead to changes in delivery time of new capabilities.

The FAA intends to use the architecture in several important ways. The agency will support the annual budget process by prioritizing funding levels of programs critical to modernization and the sustainment of legacy systems. The architecture provides alternative investment analysis starting points for new systems.

The architecture is the FAA's public commitment to modernize the NAS consistent with budgets and good management. Most importantly, the architecture forms the basis for continuing discussions and planning with the aviation industry and users. It provides the aviation industry a tool for planning the avionics upgrades that complement the new technologies and procedures envisioned for Free Flight.

This architecture estimates the time required for changing FAA regulations and certification procedures, for hardware development, and for users to equip with appropriate avionics. Reasonable assumptions have been made about the rate at which users will equip with new avionics. However, the marketplace greatly influences the aviation industry and is one factor that could affect equipage rates.

It is extremely difficult to accurately predict system performance levels when so many new technologies are being introduced at once. However, safety remains a primary consideration in modernizing the NAS and determining if/when new services will become available to users. With time, understanding of new technologies and their human factors implications will become clearer. This understanding could alter the concept of operations (CONOPS) and the architecture.

This NAS architecture would not have been possible without the help and guidance of the entire user community. The continued involvement of RTCA, the International Civil Aviation Organization (ICAO), and the Core Team is vital to shaping the future of the NAS. The FAA intends to reach new levels of trust and cooperation with NAS users, with the goal of providing the safest, most cost-effective, and efficient airspace system in the world.

PART V

APPENDIXES

APPENDIX A

LIST OF ACRONYMS

AND ABBREVIATIONS

LIST OF ACRONYMS AND ABBREVIATIONS

Bolded listings are FAA organizations.

A/A	air-air
A/G	air-ground
A/N	alphanumeric
AAF	Airway Facilities Service (FAA organization)
AAT	Air Traffic (FAA organization)
AATS	airspace analytical tool system
ABPE	automated barometric pressure entry
ACARS	Aircraft Communications Addressing and Reporting System
ACE	ASOS controller equipment
ACO	Aircraft Certification Office
ACS	Civil Aviation Security (FAA organization)
ADAS	AWOS data acquisition system
ADDS	Aviation Digital Data Service
ADF	automatic direction finder
ADS	automatic dependent surveillance
ADS-A	automatic dependent surveillance addressable
ADS-B	automatic dependent surveillance broadcast
ADSS	ATC decision support system
ADTN 2000	Administrative Data Transmission Network 2000
AERA	automated en route air traffic control
AF	Airway Facilities (FAA organization)
aFAST	active Final Approach Spacing Tool
AFB	air force base
AFOS	automation of field operations and services
AFSS	automated flight service station
AFTN	aeronautical fixed telecommunications network
AGATE	advanced general aviation transport equipment
AGFS	Aviation Gridded Forecast System
AIA	automated interface adapter
AIDC	air traffic services interfacility data communications
AIM	Airman’s Information Manual
AIP	Airport Improvement Program
AIRMET	airman's meteorological information
AIS	aeronautical information system
ALDARS	ASOS Lightning Detection and Reporting System
ALSF	approach lighting system with sequenced flashing lights
AM	amplitude modulation

AMASS	Airport Movement Area Safety System
AMS	acquisition management system
AMSS	aeronautical mobile satellite service
ANC	Air Navigation Commission
ANICS	Alaska NAS Interfacility Communications System
ANSI	American National Standards Institute
AOA	air operations area
AOAS	Advanced Oceanic Automation System
AOC	airline operations center
AOCNet	airline operations center network
AOS	Operational Support Services (FAA organization)
APB	acquisition program baseline
API	Policy, Planning and International Aviation (FAA organization)
APP	application portability profile
ARA	Research and Acquisition (FAA organization)
ARP	Airports (FAA organization)
ARSR	air route surveillance radar
ARTCC	air route traffic control center
ARTCC-P	Air Route Traffic Control Center Personnel
ARTS	automated radar terminal system
ASAS	Aviation Safety Analysis System
ASD	aircraft situation display
ASDE	airport surface detection equipment
ASDI	aircraft situation display to industry
ASIS	aviation standards information system
ASM	altimeter setting message
ASOS	automated surface observing system
ASR	Office of Spectrum Policy and Management (FAA organization)
ASR	airport surveillance radar
ASR-WSP	airport surveillance radar-weather system processor
ASRP	Aviation Safety Research Program
AST	Commercial Space Transportation (FAA organization)
ASTERIX	All Purpose Structural Eurocontrol Radar Information Exchange
AT	Air Traffic (FAA organization)
ATC	air traffic control
ATCBI	air traffic control beacon interrogator
ATCRBS	air traffic control radar beacon system
ATCSCC	Air Traffic Control System Command Center
ATCT	airport traffic control tower

ATCT-P	Airport Traffic Control Tower Personnel
ATIS	automatic terminal information service
ATM	air traffic management
ATN	aeronautical telecommunications network
ATOMS	Air Traffic Operational Management System
ATS	Air Traffic Services (FAA organization)
AVN	Aviation System Standards (FAA organization)
AVR	Regulation and Certification (FAA organization)
AW-IDS	automated weather information distribution center
AWC	Aviation Weather Center
AWN	Automated Weather Network
AWOP	All Weather Operations Panel
AWOS	automated weather observing system
AWP	aviation weather processor
AWR	Aviation Weather Research
B	billion
BD	begin decommission
bps	bits per second
BRI	basic rate interface
BUEC	backup emergency communications
CA	conflict alert
CAA	Cargo Airline Association
CAASD	Center for Advanced Aviation System Development
CAEG	computer aided engineering graphic
CAMI	Civil Aeromedical Institute
CARF	central altitude reservation function
CASA	Controller Automation Spacing Aid
CAT	category
CBA	cost-benefit analysis
CCLD	core capabilities limited deployment
CDC	computer display channel
CDM	collaborative decisionmaking
CDTI	cockpit display of traffic information
CENRAP	Center Radar ARTS Presentation
CEQ	Council on Environmental Quality
CERAP	Center Radar Approach Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act

CERFA	Community Environmental Response Facilitation Act
CFIT	controlled flight into terrain
CFR	Code of Federal Regulations
CFWARP	central flow WARP
CHI	computer-human interface
CIMS	corporate information management system
CM	conflict monitor
CMA	context management application
CMU	communications management units
CNS	communications, navigation, surveillance
CODAS	Consolidated Operations and Delay Analysis System
CONOPS	concept of operations
CONUS	continental United States
COPS	Cost Performance System
COTS	commercial off-the-shelf
CP	conflict probe
CPDLC	controller-pilot data link communications
CR	conflict resolution
CRDA	Converging Runway Display Aid
CSMA	carrier-sense multiple access
CTA	control by time of arrival
CTAS	Center TRACON (terminal radar approach control) Automation System
CTS	coded time source subsystem
CWSU	center weather surface unit
D-ATIS	digital automated terminal information services
D-Side	data side
DA	descent advisor
DAB	David A. Baker
DARC	direct access radar channel
DARP	dynamic air route planning
DASI	digital altimeter setting indicator
DBMS	data base management system
DBRITE	digital bright radar indicator tower equipment
DCCR	display channel complex replacement
DDC	direct digital connect
DDS	digital data service
DDTC	data delivery of taxi clearance
DEDS	data entry and display subsystem

DEMVAL	demonstration validation
DL	data link
DLAP	Data Link Applications Processor
DME	distance measuring equipment
DMN	data multiplexing network
DOD	Department of Defense
DOT	Department of Transportation
DOTS	Dynamic Ocean Tracking System
DOTS + (Plus)	Dynamic Ocean Tracking System Plus
DPAT	detailed policy analysis tool
DSM	display system monitor
DSR	display system replacement
DSS	decision support system
DUAT	direct user access terminal
DVFR	defense visual flight rules
E&M	ear and mouth
E-IDS	enhanced next-generation information display system
EA	environmental assessment
EARTS	En Route Automated Radar Tracking System
EDC	early display configuration
EDDA	Environmental Due Diligence Audit
EEAS	enhanced en route automation system
EFIS	electronic flight information system
EIS	environmental impact statement
ELT	emergency locator transmitter
EMC	Environmental Modeling Center
ENET	enterprise network
EOSL	end of service life
ERDI	en route domain infrastructure
ESI	enhanced DARC system interface
ETAS	enhanced terminal automation system
ETMS	enhanced traffic management system
ETN	electronic tandem network
ETVS	enhanced terminal voice switch
EVCS	Emergency Voice Communications System
F&E	facilities and equipment
FAA	Federal Aviation Administration

FAAHQ-P	Federal Aviation Administration Headquarters Personnel
FAALFI-P	Federal Aviation Administration Logistics Flight Inspection Personnel
FAATSAT	FAA telecommunications satellite
FAATC	FAA Technical Center
FANS	Future Air Navigation System
FAR	Federal Aviation Regulation
FAST	Final Approach Spacing Tool
FBWTG	FAA bulk weather telecommunications gateway
FDADS	fully digital ARTS display system
FDIO	Flight Data Input/Output
FDM	flight data management
FDP	flight data processor
FFP1 CCLD	Free Flight Phase 1 Core Capabilities Limited Deployment
FFTS	full fidelity training simulator
FICS 21	FAA Integrated Communications System for the 21st Century
FID	flight information display
FIR	flight information region
FIS	flight information service
FL	flight level
FM	frequency modulation
FMA	Final Monitor Aid
FMC	flight management computer
FMS	flight management system
FO	flight object
FOC	full operating capability
FOS	family of services
FP	flight plan
FPS	fixed position surveillance
FRAD	frame relay access device
FSAS	flight service automation system
FSC	final system capability
FSD	full-scale deployment
FSDPS	Flight Service Data Processing System
FSL	Forecast Systems Laboratory
FSM	flight schedule monitor
FSS	flight service station
FSS-P	Flight Service Station Personnel
FTS	Federal Telecommunications System

G/G	ground-ground
GA	general aviation
GAO	General Accounting Office
GDP	ground delay program
GEO	geostationary
GEOSAT	geostationary satellite
GICB	ground-initiated communications broadcast
GIS	Geographic Information System
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GNSSP	Global Navigation Satellite System Panel
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GPWS	ground proximity warning system
GSA	General Services Administration
GUI	graphic user interface
GWDS	graphic weather display system
HARS	high-altitude route system
HCS	host computer system
HF	high frequency
HFDL	high frequency data link
HID	host interface device
HOCSR	Host/oceanic computer system replacement
Host	host computer
HQ	headquarters
HSI	human-system integration
HVAC	heating, ventilation, and air conditioning
H/W	hardware
IAP	instrument approach procedures
IAPA	instrument approach procedures automation
IAIPT	interagency air traffic management integration product team
IC	initial contact
ICAO	International Civil Aviation Organization
ICE-MAN	integrated computer environment–mainframe and networking
ICP	initial conflict probe
ICSS	Integrated Communications Switching System
IDS	Information Display System

IEEE	Institute of Electrical and Electronics Engineers
IF	interface
IFQA	integrated flight quality assurance
IFR	instrument flight rules
IGWDS	Interim Graphic Weather Display System
ILS	instrument landing system
IMC	instrument meteorological condition
IMCS	interim monitoring and control system
INFOSEC	information security
INS	inertial navigation system
IOC	initial operating capability
IP	Internet protocol
IPS	Internet protocol standards
IPT	integrated product team
IRM	information resources management
ISC	initial system capability
ISD	interim situation display
ISDN	Integrated Services Digital Network
ITMRA	Information Technology Management and Reform Act of 1996
ITSC	International Training Services Center
ITWS	Integrated Terminal Weather System
JRC	Joint Resources Council
KBps	kilobytes per second
kHz	kilohertz
LAAS	Local Area Augmentation System
LAN	local area network
LCCE	life-cycle cost estimate
LDRCL	low-density radio communications link
LEO	low earth-orbiting
LIDS	legacy information distribution system
LINCS	Leased Interfacility NAS Communications System
LIS	logistics inventory system
LIU	local interface unit
LLWAS	Low-Level Windshear Alert System
LOC	localizer
Loran-C	Long Range Navigation-C System

LRR	long-range radar
M	million
M&C	monitoring and control
MAR	Managed Arrival Reservoir Program
MC	multicenter
M1FC	Model 1 Full Capacity
MALSR	medium-intensity approach lighting system with runway alignment indicator lights
MARS	managed arrival reservoir
MASPS	minimum aviation system performance standards
MASS	maintenance automation system software
MBO (AIS)	military base operations (aeronautical information system)
MCC	maintenance control center
MCI	Mode-C intruder
MDCRS	Meteorological Data Collection and Reporting System
MDT	maintenance data terminal
MED	managed evolutionary development
MEO	medium earth-orbiting
MFD	multifunctional display
MHz	megahertz
MicroEARTS	Microprocessor En Route Automated Radar Tracking System
MIGFA	machine intelligent gust front algorithm
MIT/LL	Massachusetts Institute of Technology/Lincoln Laboratory
MLS	microwave landing system
MMAC	Mike Monroney Aeronautical Center
MMS	maintenance management system
MNS	mission need statement
Mode-S	Mode-Select (secondary radar discretely addressable mode with data link)
MOPS	minimum operational performance standard
MOU	memorandum of understanding
MPAR	multipurpose airport radar
MPS	maintenance processor subsystem
MSAW	minimum safe altitude warning
MSN	message switch network
NADIN	National Airspace Data Interchange Network
NAIMS	National Airspace Information Monitoring System
NAS	National Airspace System
NASMAP	NAS management automation program

NAS RD	NAS Requirements Document
NASA	National Aeronautics and Space Administration
NASDAC	NAS Data Analysis Center
NASPAS	NAS Performance Analysis System
NATCA	National Air Traffic Controllers Association
Navaid	navigation aid
NCAR	National Center for Atmospheric Research
NCEP	National Center for Environmental Prediction
NDB	nondirectional beacon
NDI	nondevelopmental item
NEPA	National Environmental Policy Act
NESDIS	National Environmental Satellite, Data, and Information Service
NEXCOM	next-generation air-ground communications system
NEXRAD	next-generation weather radar
NIC	network interface card
NIM	NAS infrastructure management
NIS	NAS-Wide Information System
NIST	National Institute of Standards and Technology
NLDN	National Lightning Detection Network
NMAC	near midair collision reports
NMCC	National Maintenance Coordination Center
nmi	nautical mile
NMS	NAS management subsystem
NNCC	national network control center
NOAA	National Oceanic and Atmospheric Administration
NOCC	national operations control center
NOPAC	North Pacific Ocean
NORAD	North American Aerospace Defense Command
NOTAM	notice to airmen
NPIAS	National Plan of Integrated Airport Systems
NPF	NIM premier facility
NPR	National Performance Review
NRC	National Research Council
NRP	National Route Program
NSF	National Science Foundation
NSSL	National Server Storms Laboratory
NTSB	National Transportation Safety Board
NWS	National Weather Service
NWSTG	NWS telecommunications gateway

OAG	Official Airline Guide
OASIS	Operational and Supportability Implementation System
OATS	Office Automation Technology Services
OCC	operations control center
OCS	offshore computer system
OCS-R	offshore computer system rehost
ODAPS	Oceanic Display and Planning System
ODID	operational display and input development
ODL	oceanic data link
ODMS	Operational Data Management System
OE/AAA	obstruction evaluation/airspace and airport analysis
OFDPS	Offshore Flight Data Processing System
OMB	Office of Management and Budget
OPI	office of primary interest
OPS	operations
ORD	operational readiness demonstration
ORMT	Operations Resource Management Team
OS&H	occupational safety and health
OSO	Office of System Operations
OTMS	Oceanic Traffic Management System
P^3I	preplanned product improvement
PABX	public automatic branch exchange
PAMRI	peripheral adapter module replacement item
PAPI	precision approach path indicator
PASS	Professional Airways Systems Specialists (union)
PBX	private branch exchange
PCB	polychlorinated biphenyl
PCB&T	Personnel, Compensation, Benefits and Travel
PDC	predeparture clearance
PDE-P	Planning, Development, and Evaluation Personnel
PDM	predefined message
PDT	product development team
pFAST	passive final approach spacing tool
PFC	Passenger Facility Charge
PIDP	Programmable Indicator Processor
PIREP	pilot report
PMCS	programmable modular communications system

PNIM	prototype NIM
PPS	precise positioning service
PPSS	Portable Performance Support System
PRI	primary rate interface
PRM	parallel runway monitor
PSN	packet switch network
PVD	plan view display
R-side	radar side
RADS	radar and alphanumeric display subsystem
RAIM	receiver autonomous integrity monitoring
RCAG	remote communications air-ground
RCE	radio control equipment
RCL	radio communications link
RCOM	recovery communications
RD	Requirements Document
RDA	radar data acquisition
RDP	radar data processing
RDVS	rapid deployment voice switch
R,E&D	research, engineering, and development
REDAC	Research, Engineering, and Development Advisory Committee
REGIS	Regional Information Service
REQIS	requirements information system
RFDP	replacement flight data printers
RGCSP	Review of the General Concept of Separation Panel
RIR	runway incursion reduction
RMC	Resource Management Council
RMMS	remote maintenance monitoring system
RMS	remote maintenance sensor
RNAV	area navigation
RNP	required navigation performance
ROCC	regional operational command center (NORAD)
RPG	radar product generator
RTA	required time of arrival
RTCA	RTCA, Incorporated
RTR	radio transceiver
RVR	runway visual range
RVSM	reduced vertical separation minima

SAIDS	Systems Atlanta Information Display System
SAMS	special use airspace management system
SAR	search and rescue
SARP	standard and recommended practices
SATCOM	satellite communications
SAT NAV	satellite navigation
SC	single center
SDP	surveillance data processor
SEOAT	System Engineering Operational Analysis Team
SFO	San Francisco International Airport
SI	selective interrogation
SIAP	standard instrument approach procedures
SIGMET	significant meteorological information
SLEP	service life extension program
SLIM	software life-cycle model
SMA	Surface Movement Advisor
SMO	system maintenance and operations
SMS	surface management system
SOC	service operations center
SPAS	Safety Performance Analysis Subsystem
SSC	system service component
SSR	secondary surveillance radar
STAR	space transportation analysis and research
STARS	Standard Terminal Automation Replacement System
STC	supplemental type certificate
STDMA	self-organized time division multiple access
STVS	small tower voice switch
SUA	special use airspace
S/W	software

TACAN	tactical air navigation
TAWS	Terrain Alert and Warning System
TCA	two-controller access
TCAS	Traffic Alert and Collision Avoidance System
TCW	terminal controller workstation
TDLS	tower data link services
TDSS	TFM Decision Support System
TDW	tower display workstation
TDWR	terminal Doppler weather radar

TERP	terminal instrument procedures
TFM	traffic flow management
TIS	Traffic Information Service
TMA	Traffic Management Advisor
TMA MC	Traffic Management Advisor Multicenter
TMA SC	Traffic Management Advisor Single Center
TMC	traffic management coordinator
TML	television microwave link
TMS	traffic management specialist
TMU	traffic management unit
TOC	transfer of communications
TP	telecommunications processor
TRACON	terminal radar approach control
TRM	technical reference model
TSO	technical standard order
TWDL	two-way data link communications
TWIP	Terminal Weather Information for Pilots
TWS	Terminal Weather Service
U.S.	United States
U.S.C.	United States Code
UAT	universal access transceiver
UHF	ultra high frequency
URET CCLD	User Request Evaluation Tool core capabilities limited deployment
VASI	visual approach slope indicator
VDL	very high frequency digital link
VFR	visual flight rules
VHF	very high frequency
VOR	VHF omnidirectional range
VORTAC	VOR co-located with TACAN facilities
VPD	vehicle/pedestrian deviation
VPN	virtual private network
VSCS	voice switching and control system
VSRS	Voice Switch Replacement System
WAAS	Wide Area Augmentation System
WAN	wide area network
WARP	weather and radar processor

WC	work center
WIC	weather in the cockpit
WIS	Workload Information System
WJHTC	William J. Hughes Technical Center
WMSCR	weather message switching center replacement
WS	workstation
WSDDM	weather support to de-icing decisionmaking
WSP	weather system processor
WV	Wake Vortex
Wx	weather
WxP	weather processor
Y2K	Year 2000
ZAN	Anchorage ARTCC
ZHN	Honolulu ARTCC
ZSU	San Juan ARTCC

APPENDIX B

PARTICIPATING ORGANIZATIONS

PARTICIPATING ORGANIZATIONS

The NAS architecture was developed during 1997 and 1998, with the participation of internal FAA and external organizations. This appendix provides a list of those organizations whose contribution or support was instrumental to the development of the NAS architecture. This appendix is not a complete list of participating organizations but provides an indication of the scope of involvement. The routing symbols by each organization identify the unique organizations that supported the architecture development.

Internal FAA Organizations

System Safety Office - ASY

Associate Administration for Policy, Planning, and International Aviation

- Office of Aviation Policy and Plans - APO
- Office of Environment and Energy - AEE
- Office of International Aviation - AIA

Associate Administrator for Commercial Space Transportation - AST

Associate Administrator for Administration

- Office of Business Information and Consultation - ABC
- Office of Financial Services - ABA
- Office of Human Resources Management - AHR

Associate Administration for Airports

- Office of Airport Planning and Programming - APP
- Office of Airport Safety and Standards - AAS

Associate Administrator for Civil Aviation Security

- Office of Civil Aviation Security Policy and Planning - ACP
- Office of Civil Aviation Security Operations - ACO

Associate Administration of Regulation and Certification

- Aircraft Certification Service - AIR
- Flight Standards Service - AFS

Associate Administration for Air Traffic Services

- Director Air Traffic Services
  - Air Traffic Airspace Management - ATA
  - Air Traffic Operations Program - ATO
  - Air Traffic Resource Management Program - ATX
  - Air Traffic Systems Requirements Service - ARS
    - Requirements Development Program - ARR
    - Plans and Performance - ARX
- Director Airway Facilities Service
  - NAS Operations Program Directorate - AOP
  - Resource Management Directorate - AFZ

NAS Transition and Implementation - ANS
Operations Support Service - AOS
Spectrum Policy and Management - ASR
Aviation System Standards - AVN

Office of System Capacity - ASC

Associate Administration for Research and Acquisition

Office of Acquisitions - ASU
Office of Air Traffic Systems Development - AUA
Office of Aviation Research - AAR
Office of Business Management - ABZ
Office of Communications Navigation, and Surveillance Systems -AND
Office of Information Technology - AIT
Office of System Architecture and Investment Analysis - ASD
William J. Hughes Technical Center - ACT
Office of Free Flight Phase 1

Mike Monroney Aeronautical Center - AMC

FAA Academy - AMA
FAA Logistics Center - AML

External Organizations

SETA (System Engineering and Technical Assistance contractor (TRW, ARINC, CTA, NYMA, RMS, SAIC, JTA, PMA))

CSSI

MITRE Corporation/Center for Advanced Aviation System Development (CAASD)

Massachusetts Institute of Technology (MIT)

RTCA and participating members

Research, Engineering, and Development Advisory Committee

Department of Defense

Department of Transportation

APPENDIX C

LIST OF REFERENCES

AND

SUPPLEMENTAL MATERIAL

LIST OF REFERENCES AND SUPPLEMENTAL MATERIAL

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APPENDIX D

NAS CAPABILITIES

AND MATRIX

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NAS CAPABILITIES

D.1 NAS Capabilities Diagrams

1. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services, Arrival/Departure

Figures D-1 and -2 show Phases 1 and 2, respectively, of this capability.

Phase 1 (1998–2002)

- Improved position accuracy is obtained by using range and time data from the Global Positioning System (GPS) as well as GPS correction and integrity information (Wide Area Augmentation System (WAAS)). GPS correction and integrity information from ground systems (WAAS) is relayed through satellites to ensure the signal in space will provide coverage for aircraft at various altitudes. The aircraft's location is displayed to pilots. GPS equipment and GPS augmentation enhance aircraft area navigation (radionavigation) capability for point-to-point flight routes.
- Improved precision approach capability using satellite-based navigation instrument approaches allows precision approaches to category (CAT) I minima at more airports. Satellite-based navigation instrument approaches allow multiple approach paths to many runways. The existing instrument landing systems remain in place during this period.
- Runway and approach lighting systems continue to provide the visual transition from cockpit instrumentation to visual landing during touchdown and rollout. Airport lighting remains a key element to sustaining flight operations during reduced visibility conditions.
- Provides WAAS precision approaches to airports that currently have existing CAT I or other approaches. Actual approach minima will continue to be based on obstacle clearance, lighting, etc.
- Provides WAAS precision approaches to airports that currently do not have precision approaches. Actual approach minima will continue to be based on obstacle clearance, lighting, etc.

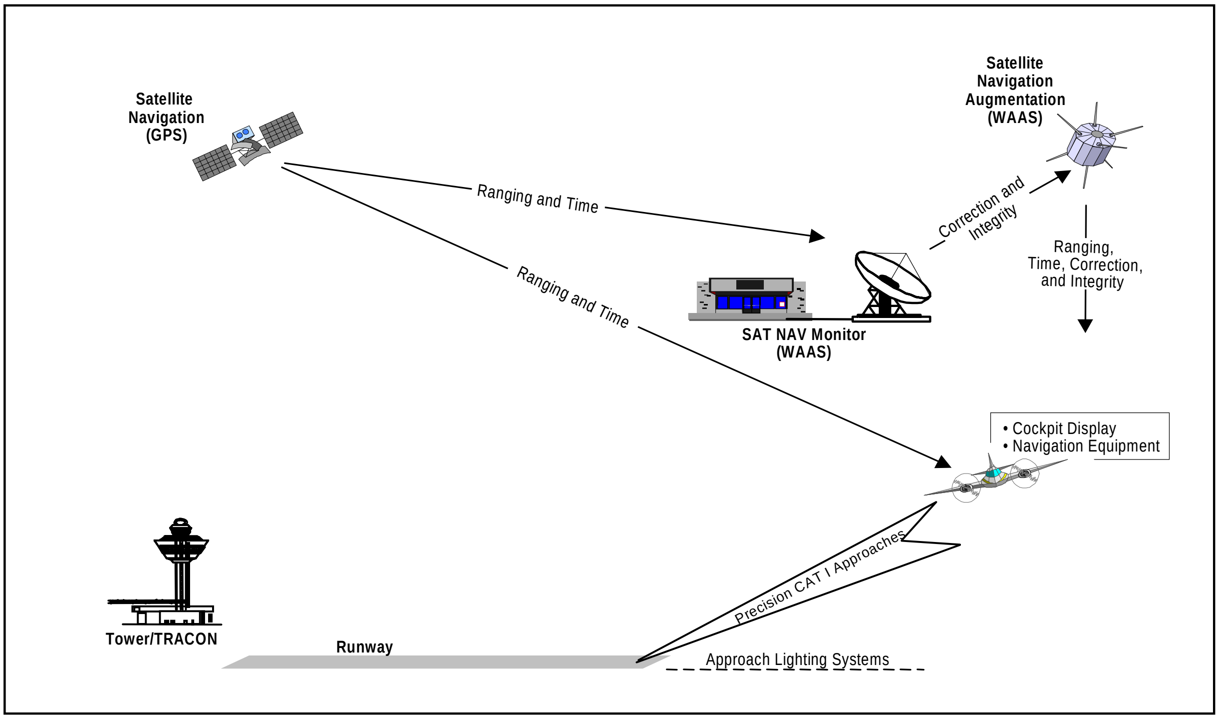

Figure D-1. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services, Arrival/Departure, Phase 1 (1998–2002)

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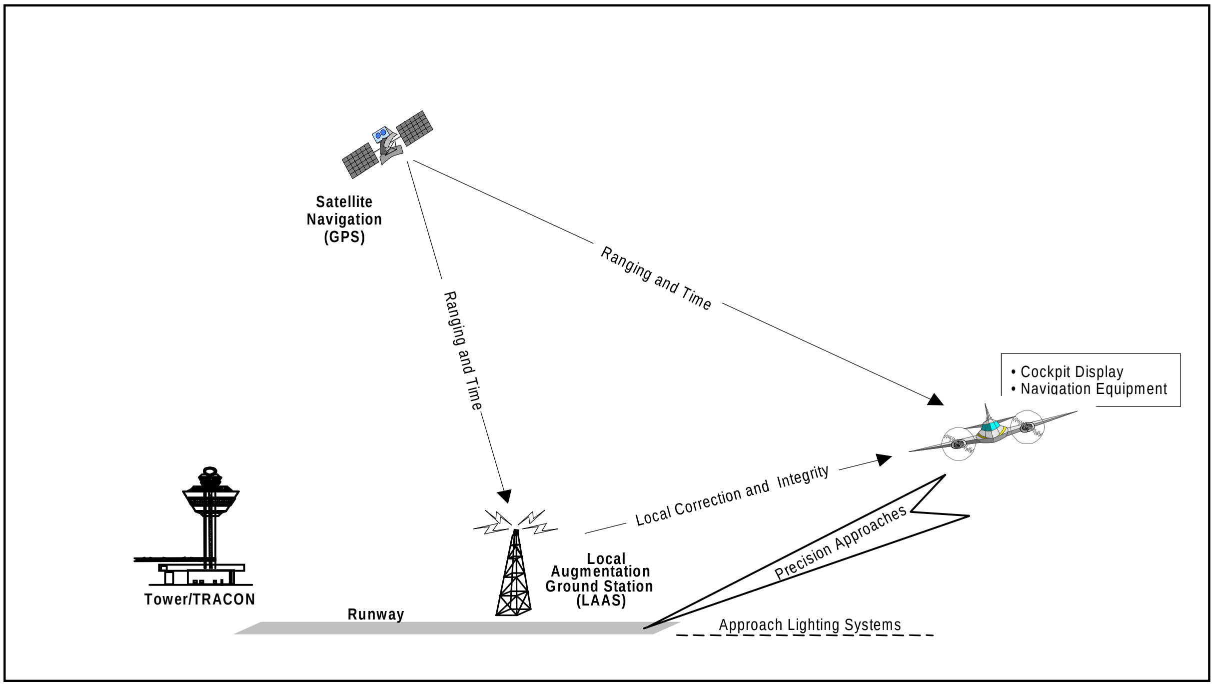

Figure D-2. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services, Arrival/Departure, Phase 2 (2003–2007)

- Site availability is improved due to the increase in CAT I approaches available at potential alternate landing sites.

Phase 2 (2003–2007)

- Satellite-based navigation will be locally augmented to provide increased precision guidance accuracy, integrity, and availability.
- Local GPS augmentation allows for CAT II/III precision approach capability and for increased availability of CAT I approaches.

Phase 3 (2008–2015)

- No additional change in capability.

1. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services, Oceanic

Figure D-3 shows Phase 1 of this capability.

Phase 1 (1998–2002)

- Improved position accuracy is obtained by using range and time data from GPS. The location will be displayed for the pilot.
- Inertial guidance systems and satellite-based navigation equipment are available to support area navigation operations aboard properly equipped aircraft. This provides a more precise and reliable means of navigation during long flights over water.

Phase 2 (2003–2007)

- No additional changes in capability.

Phase 3 (2008–2015

- Same functionality as En Route/Cruise.

1. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services, NAS-Wide

Figure D-4 shows Phase 1 of this capability.

Phase 1 (1998–2002)

- Improved position accuracy is obtained by using range and time data from GPS, and GPS correction and integrity information from WAAS. GPS correction and integrity information from ground systems (WAAS) is relayed through satellites to ensure the signal in space will provide coverage for aircraft at various altitudes. The aircraft's location is displayed to pilots. GPS equipment and GPS augmentation provide vertical reference and enhance aircraft area navigation (RNAV) capability for point-to-point flight routing.

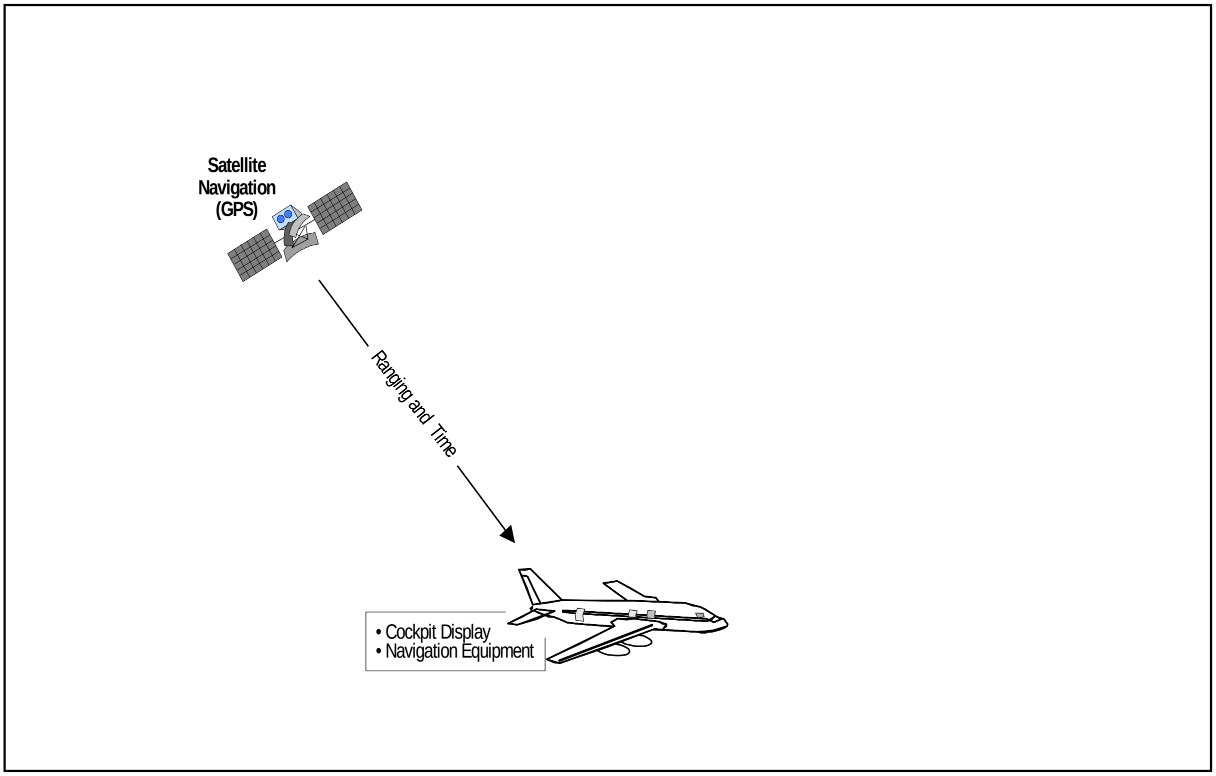

Figure D-3. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services, Oceanic, Phase 1 (1998–2002)

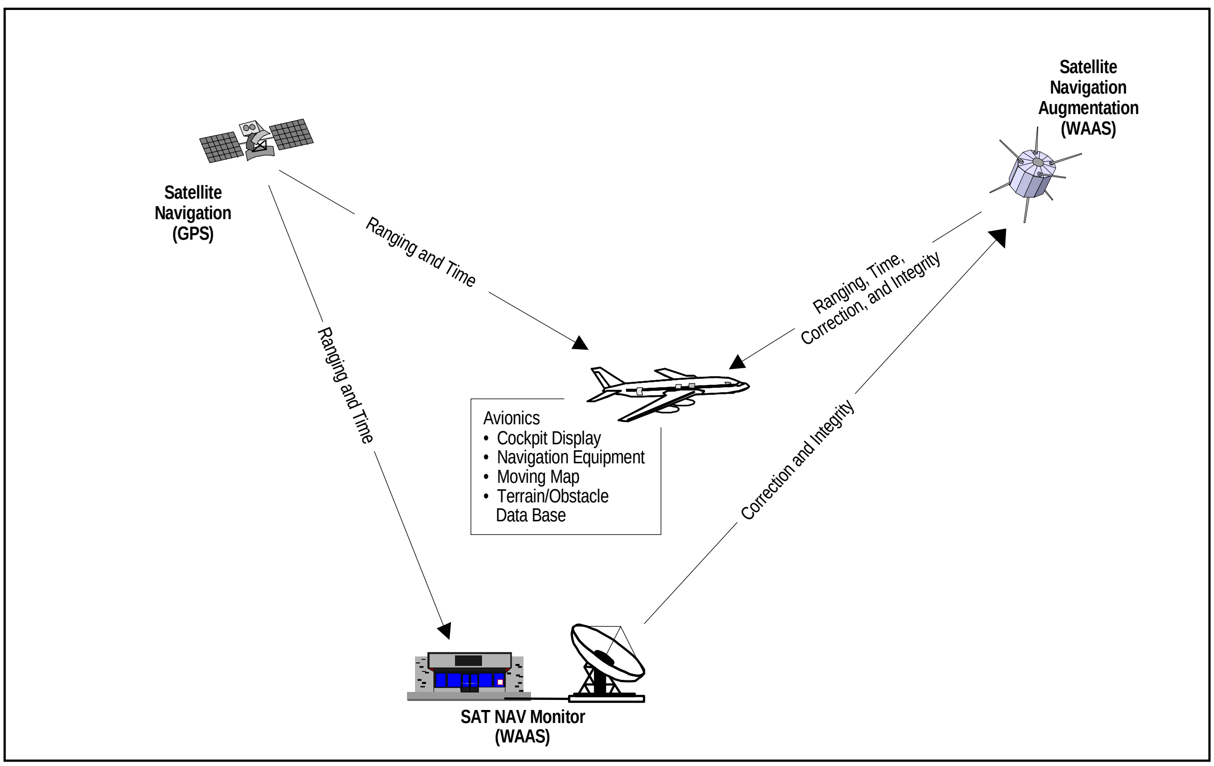

Figure D-4. Increased Navigation/Landing Position Accuracy and Site Availability, Air Traffic Services, NAS-Wide, Phase 1 (1998–2002)

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- Avionics enhancements could include moving terrain map and position display on the cockpit displays.
- An enhanced terrain awareness warning system (TAWS) provides pilots with more ground proximity warning time.

Phase 2 (2003–2007)

- No additional change in capability.

Phase 3 (2008–2015)

- No additional change in capability.

2. Increased Exchange of Common Weather Data, Air Traffic Services, Arrival/Departure

Figures D-5, -6, and -7 show Phases 1, 2, and 3, respectively, of this capability.

Phase 1 (1998–2002)

- In-flight graphical terminal weather information (TWIP) is provided to pilots based on weather radar data (TDWR, ASR-9 WSP) relayed through a service provider. This service is primarily for commercial carriers.
- Local weather radar, sensor information, and National Weather Service (NWS) weather products are integrated for improved distribution.
- The integrated weather products are distributed to other facilities (i.e., terminal radar control facility (TRACON), automated flight service station (AFSS), air route traffic control center (ARTCC), Department of Defense (DOD)) for rapid dissemination to all users who need the information. Ground weather observation data are broadcast directly to the aircraft operating in the local area.
- Weather information, including pilot reports (PIREPs), is transmitted to the cockpit via existing very high and ultra high frequency (VHF/UHF) radios. This will continue to meet the needs of aircraft not equipped to receive digital weather data.

Phase 2 (2003–2007)

- Integrated weather data are displayed on the service provider's workstation.

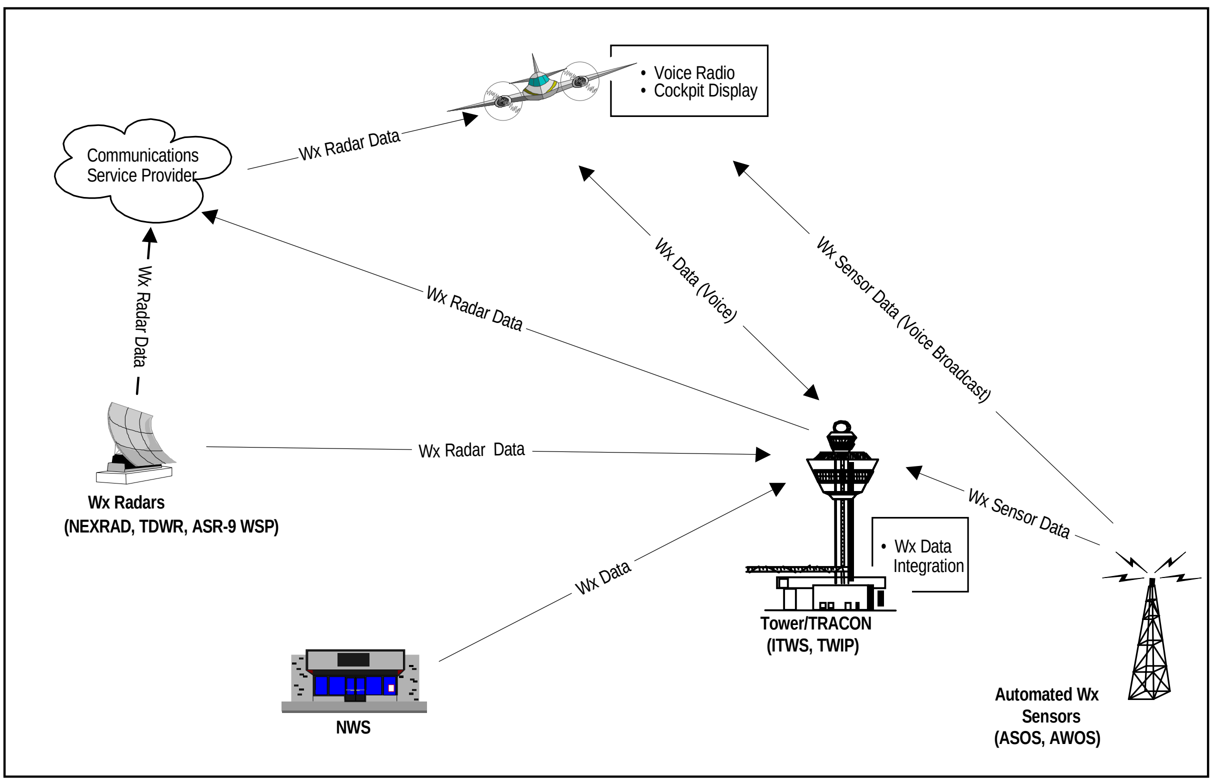

Figure D-5. Increased Exchange of Common Weather Data, Air Traffic Services, Arrival/Departure, Phase 1 (1998–2002)

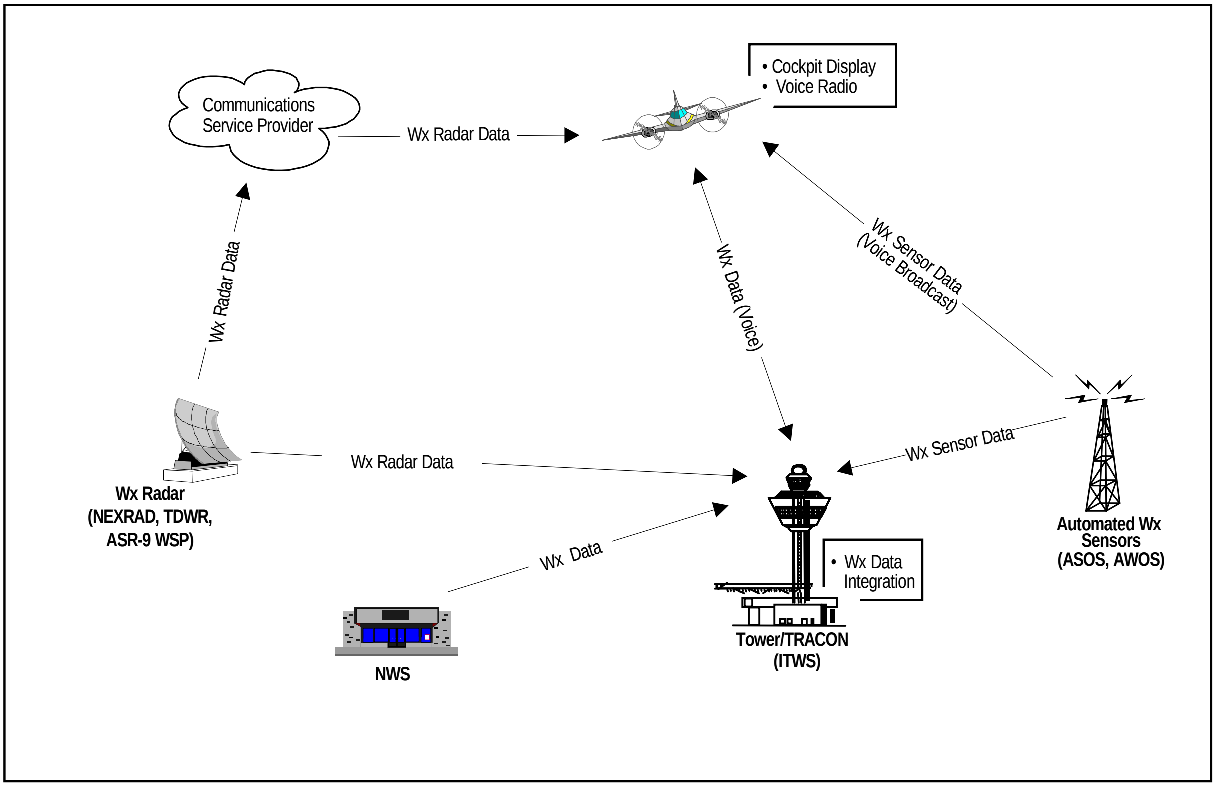

Figure D-6. Increased Exchange of Common Weather Data, Air Traffic Services, Arrival/Departure, Phase 2 (2003–2007)

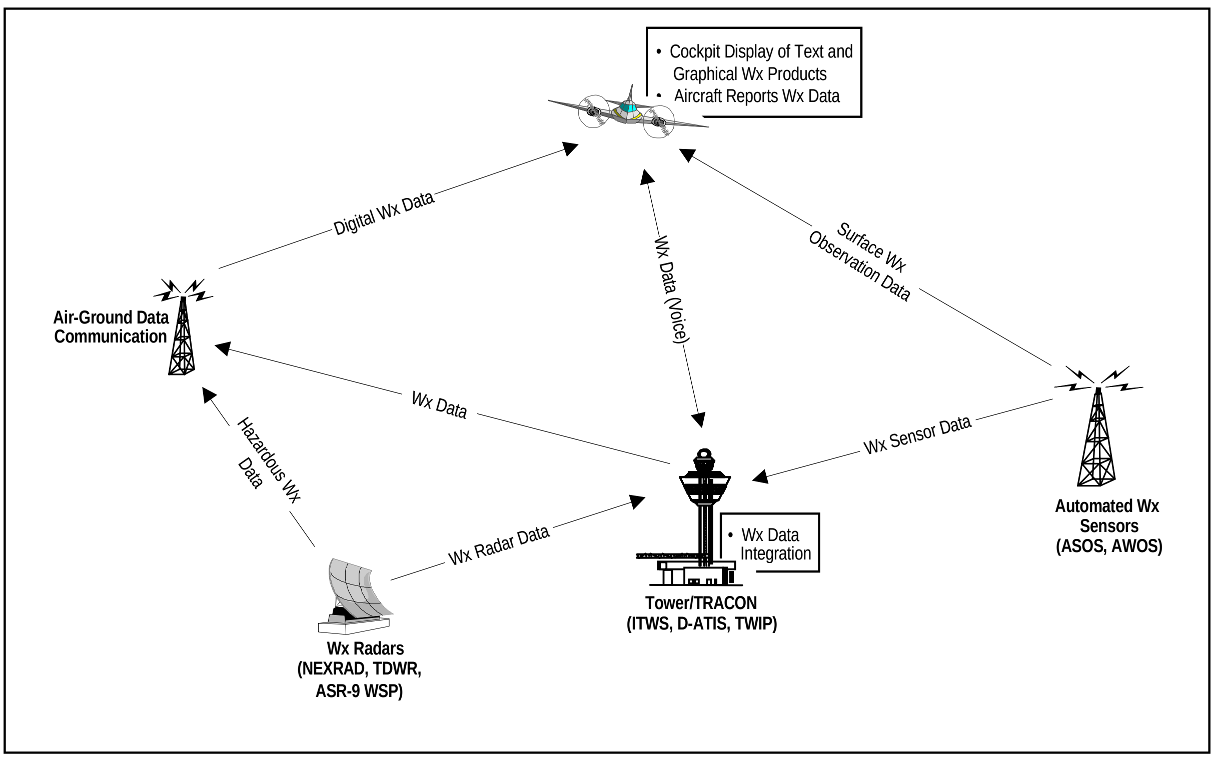

Figure D-7. Increased Exchange of Common Weather Data, Air Traffic Services, Arrival/Departure, Phase 3 (2008–2015)

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- Service provider workload is reduced as the weather and air traffic information is presented on a common display.
- Terminal weather systems will continue to produce new and improved weather products.

Phase 3 (2008–2015)

- Provides real-time windshear alert information to pilots and service providers automatically and simultaneously.

2. Increased Exchange of Common Weather Data, Air Traffic Services, En Route/Cruise

Figure D-8 shows Phase 1 of this capability.

Phase 1 (1998-2002)

- Weather information is available in the cockpit to users at all levels of avionics/communications equipage based on improved availability/access to center (ARTCC) and flight service station (FSS/AFSS) service providers. Data from multiple weather sensing sources are integrated at the ARTCC and displayed on en route service providers' workstations. In the ARTCC, traffic management specialists see terminal weather information, and the ARTCCs distribute integrated weather products to AFSSs and the NWS.
- Terminal weather information is exchanged within the ARTCCs to provide a common weather data picture among terminal and en route service providers.
- Users continue to observe and disseminate weather information. Pilots continue to provide information to the ARTCC or AFSS about in-flight conditions in pilot voice reports (PIREPS).
- Weather information exchange between pilots and service providers continues via existing radios.

Phase 2 (2003–2007)

- No additional change in capability.

Phase 3 (2008–2015)

- No additional change in capability.

2. Increased Exchange of Common Weather Data, Air Traffic Services, NAS-Wide

Figure D-9 shows Phase 1 of this capability.

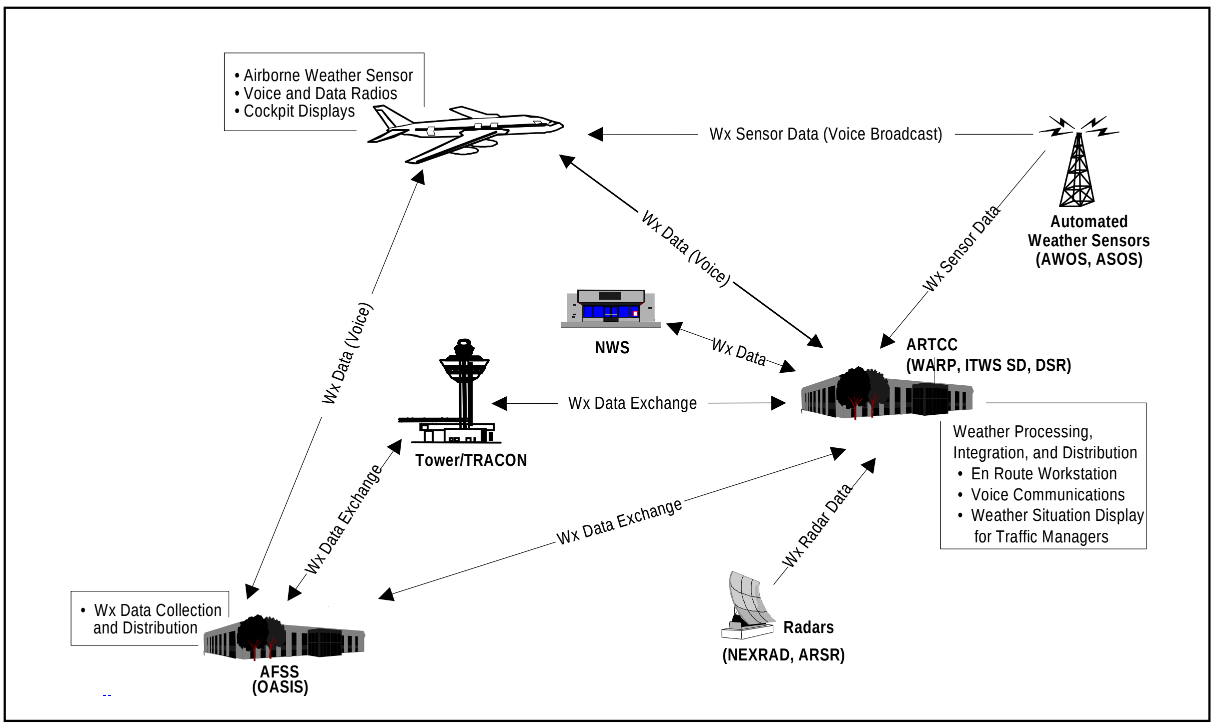

Figure D-8. Increased Exchange of Common Weather Data, Air Traffic Services, En Route/Cruise, Phase 1 (1998–2002)

Phase 1 (1998–2002)

- Some commercial aircraft act as weather sensors, providing real-time wind, temperature, and humidity data for improved weather forecasting and traffic planning.
- A collection of in-flight weather data is transmitted to the NWS from properly equipped aircraft. The NWS processes the information at its modeling centers, constantly updating computer models with new data to provide improved hourly forecasts of aviation-impacting weather.
- Private vendors provide weather data as part of the flight information service (FIS). Some air crews have access to both textual weather updates and graphical weather displays.

Phase 2 (2003–2007)

- No additional change in capability.

Phase 3 (2008–2015)

- No additional change in capability.

3. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, Tower/Airport Surface

Figures D-10, -11, and -12 show Phases 1, 2, and 3, respectively, of this capability.

Phase 1 (1998–2002)

- At the busiest airports, the airport surface detection equipment (ASDE) provides controllers with primary radar targets to display the position of aircraft and vehicles operating on airport taxiways and runways. ASDE with the airport movement area safety system (AMASS) provides target information and alerts controllers to potential collision situations in the airport movement area.
- Safety is increased by providing conflict detection alerts and improving controllers' situational awareness, particularly in low-visibility conditions.

Phase 2 (2003-2007)

- At airports that do not have ASDE/AMASS, but are large enough to qualify for the runway incursion reduction program, primary radar data will be provided to controllers to help avoid runway incursions.
- Airport markings, signage, and lighting will be improved. Also, improvements will be made in the training for pilots about runway markings, signage, and lights.

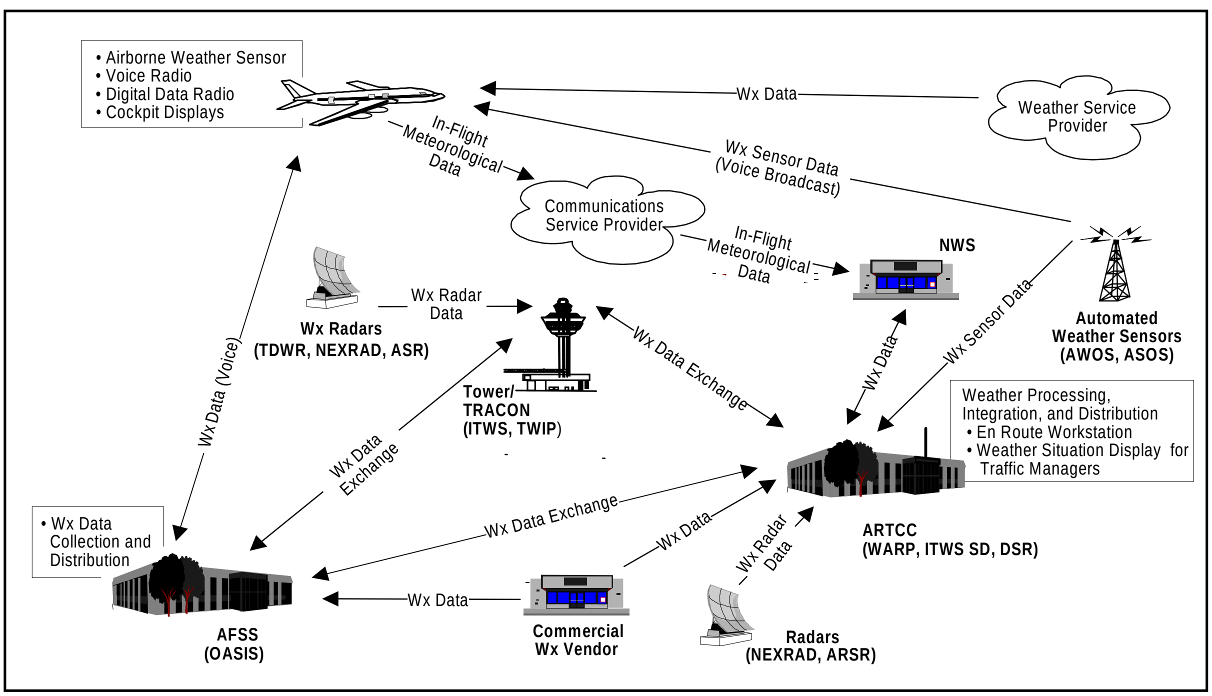

Figure D-9. Increased Exchange of Common Weather Data, Air Traffic Services, NAS-Wide, Phase 1 (1998–2002)

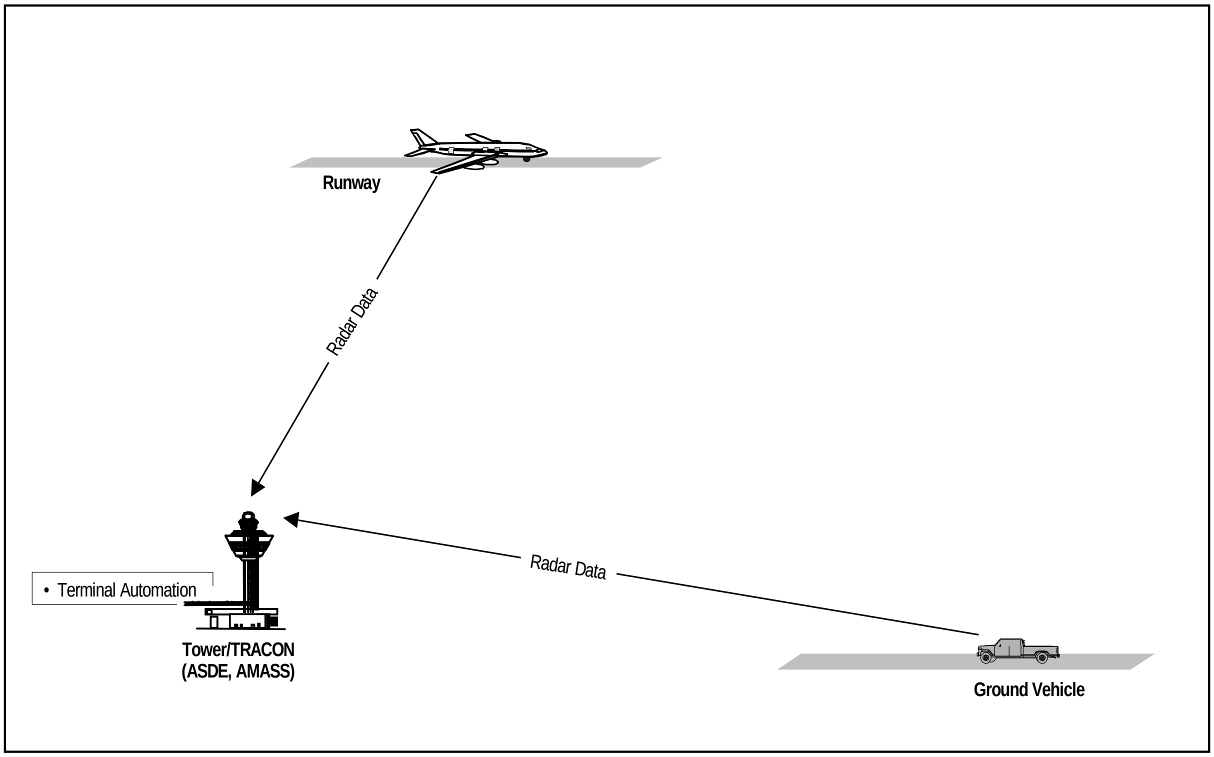

Figure D-10. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, Tower/Airport Surface, Phase 1 (1998–2002)

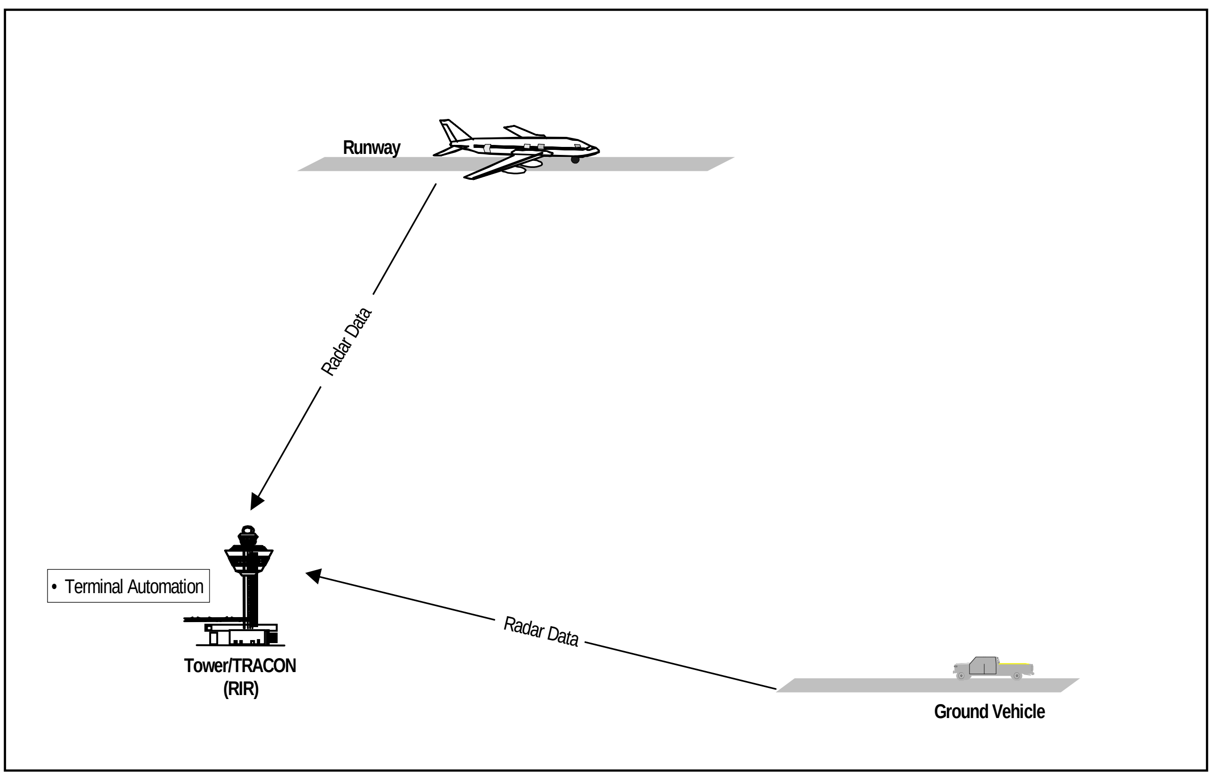

Figure D-11. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, Tower/Airport Surface, Phase 2 (2003–2007)

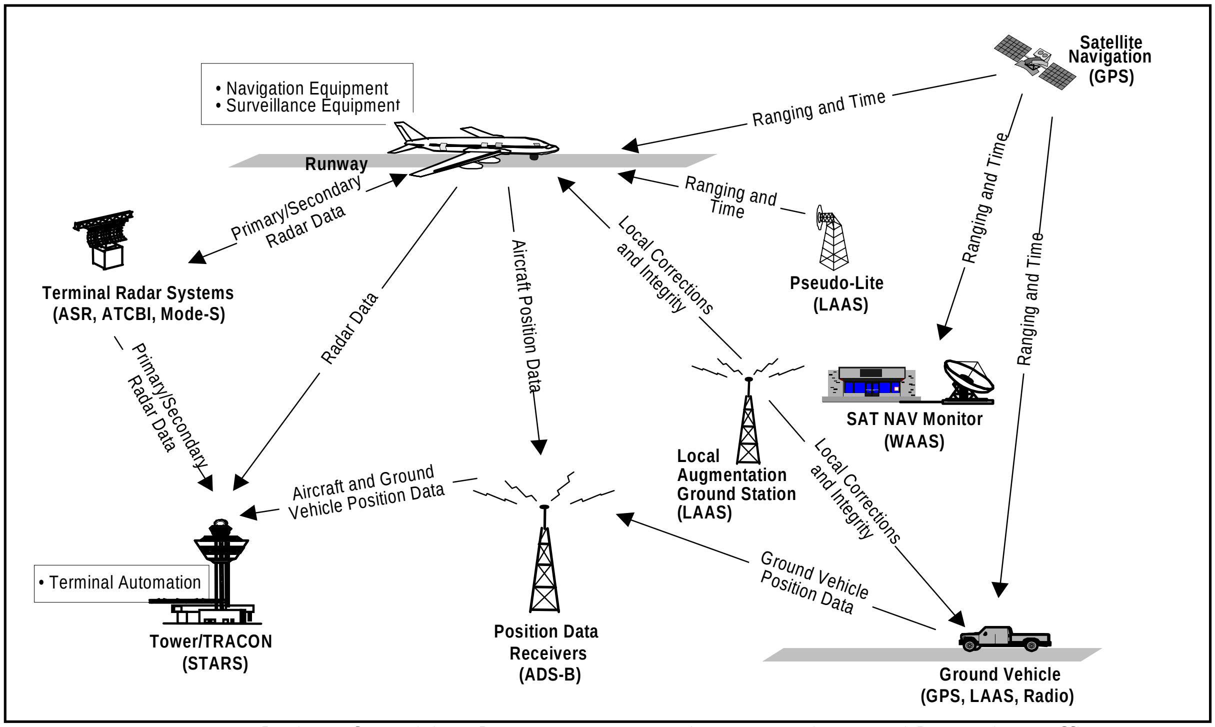

Figure D-12. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, Tower/Airport Surface, Phase 3 (2008–2015)

- Airport surveillance monitoring is more effective as surface surveillance accuracy is enhanced by the introduction of augmented GPS reports from aircraft and vehicular traffic.

Phase 3 (2008–2015)

- Integrated Tower Area Surveillance provides controllers better position information about the air traffic based on GPS. It also provides controllers integrated information about the arriving aircraft and airport surface aircraft.

3. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, Arrival/Departure

Figures D-13 and -14 show Phases 1 and 2, respectively, of this capability.

Phase 1 (1998–2002)

- Aircraft position accuracy reporting to service providers is improved.

Phase 2 (2003–2007)

- Terminal secondary surveillance radar (SSR) will be upgraded with the All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX) surveillance and weather message transfer protocol. This upgrade will allow the aircraft navigational system and waypoint data (i.e., ADS-B data) received in ground-initiated Comm B (GICB) replies to be processed. Selective interrogation (SI) capability allows the air traffic control (ATC) automation to use the unique Mode-S transponder identification code permanently assigned to an aircraft. SI also eliminates false data from the controller’s display.
- Integrated terminal surveillance with ADS-B provides controllers better position information about air traffic based on GPS.

Phase 3 (2008–2015)

- No additional change in capability.

3. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, En Route/Cruise

Figure D-15 shows Phase 2 of this capability.

Phase 1 (1998–2002)

- No change in capability.

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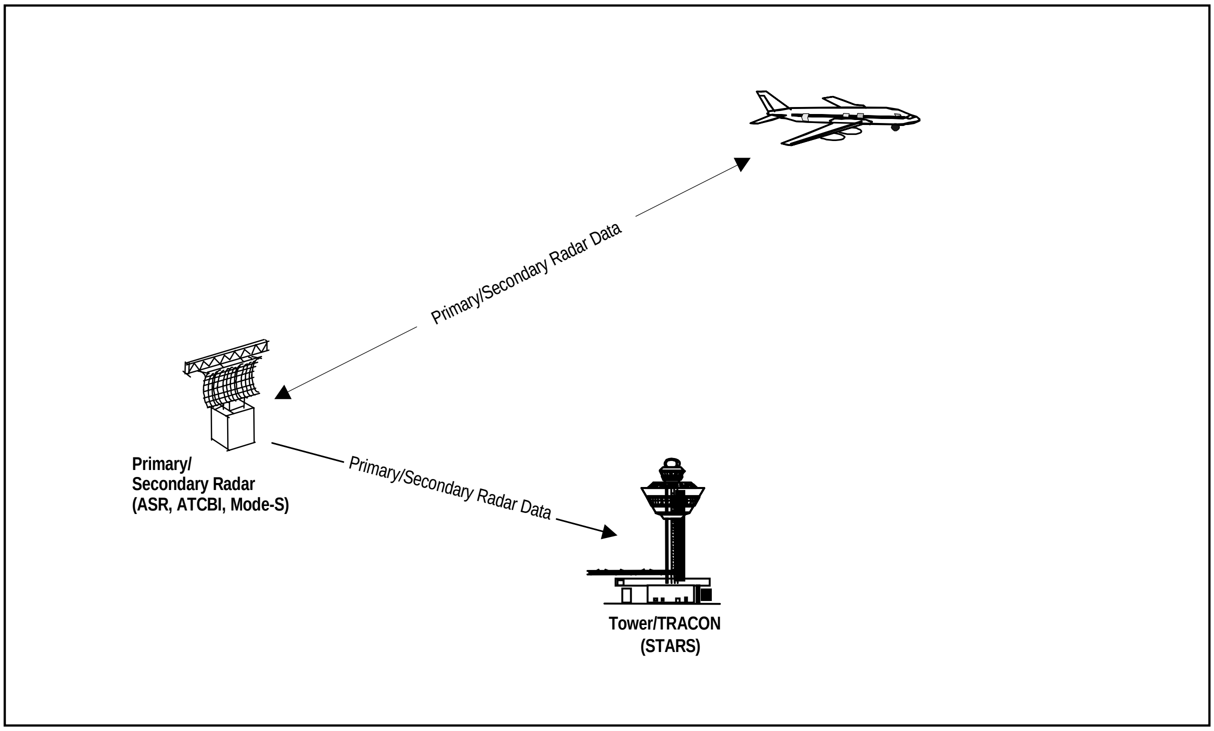

Figure D-13. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, Arrival/Departure, Phase 1 (1998–2002)

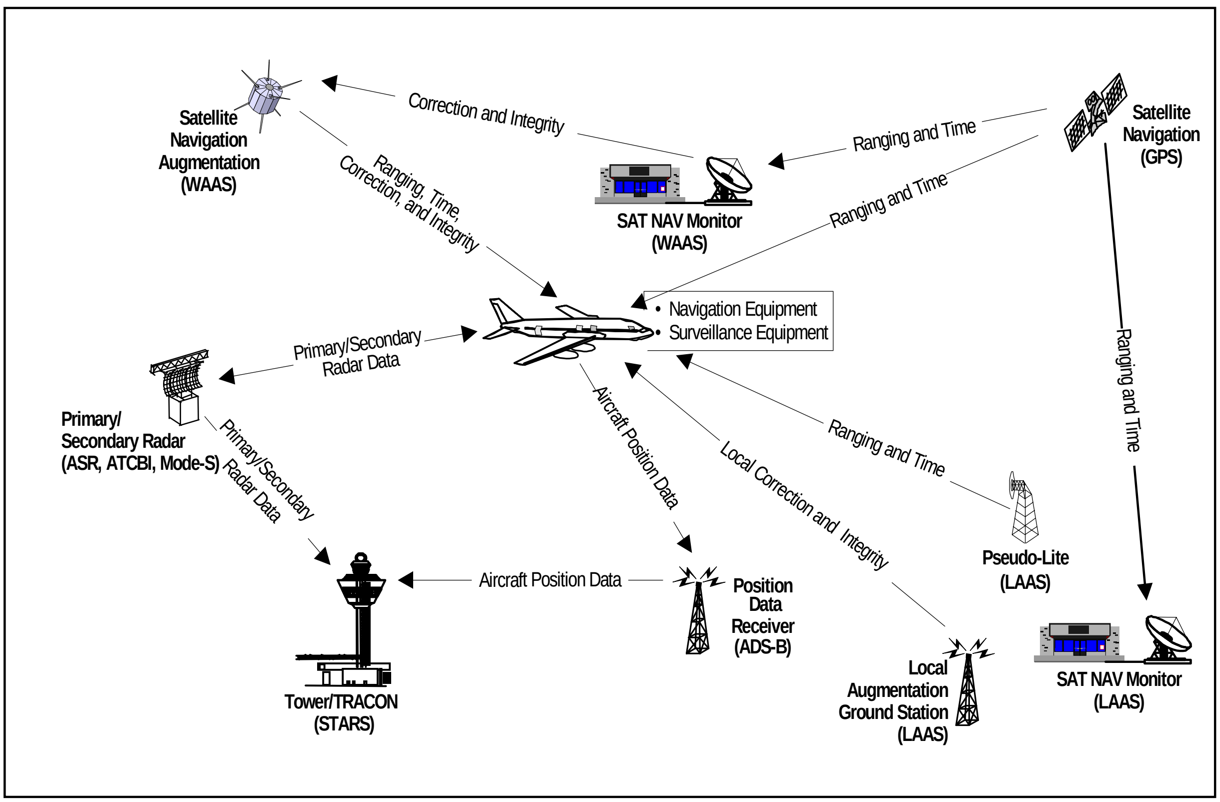

Figure D-14. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, Arrival/Departure, Phase 2 (2003–2007)

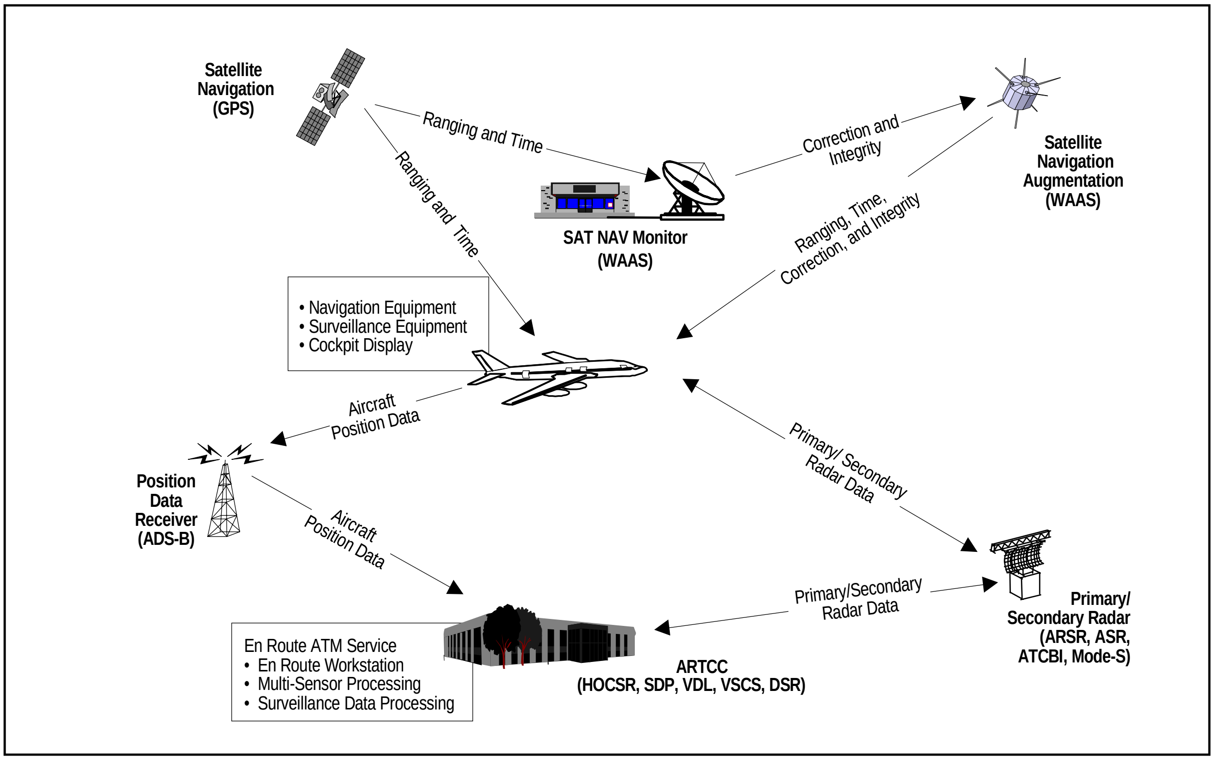

Figure D-15. Improved Aircraft Positional Accuracy Reporting to Service Providers, Air Traffic Services, En Route/Cruise, Phase 2 (2003–2007)

Phase 2 (2003–2007)

- Improved en route surveillance enhances aircraft position accuracy and intent information reporting to service providers. En route surveillance radar will be upgraded with the ASTERIX surveillance and weather message transfer protocol with SI capability. Integrating en route surveillance radar with automatic dependent surveillance broadcast (ADS-B) data provides controllers with better air traffic position information.

- More accurate flight monitoring is provided by widespread use of satellite navigation, improved radar, and the introduction of ADS-B ground processing.

- The position data processing includes combining targets from multiple types of sensors. Data sources include primary and secondary radar systems and ADS-B data.

Phase 3 (2008–2015)

- No additional change in capability.

4. Increased Self-Separation by Properly Equipped Aircraft, Air Traffic Services, NAS-Wide

Figure D-16 shows Phase 1 of this capability.

Phase 1 (1998–2002)

- More accurate position data allow more opportunities for self-separation by increasing flight crew's situational awareness. The satellite-based navigation system determines position from satellite signals and broadcasts the position information. Cockpit display of traffic information (CDTI) from ADS-B permits self-separation maneuvers, such as in-trail climbs. ADS-B provides pilots a cockpit display of traffic information of other ADS-B-equipped aircraft.

- The Mode-S transponder uses beacon-interrogation of nearby aircraft to determine their range, bearing, and altitude. The Traffic Alert And Collision Avoidance System (TCAS) then predicts possible conflicts and displays them to the pilot. Traffic conflict alert technologies currently aboard aircraft provide traffic alerts and resolution advisories to

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flight crews. The resolution function provides advisories to climb or descend to avoid the traffic.

- In domestic airspace, pilots may use ADS-B air-air surveillance for situational awareness and limited shared responsibility for separation.
- In oceanic airspace, ADS-B may be approved as a means for pilots to conduct in-trail climbs, descents, and passing maneuvers.
- Aircraft separation is still performed on the ground. To resolve detected conflicts, pilots coordinate anticipated clearance deviations with ATC service providers before taking action.
- Traffic information service via Mode-S provides air traffic surveillance information to properly equipped in-flight aircraft using Mode-S.
- Air-air ADS-B and TCAS traffic information displays aid the pilot during in-trail climbs. Figure D-16 shows an example of self-separation. The aircraft on the left intends to climb past the other aircraft.

Phase 2 (2003–2007)

- No additional change in capability.

Phase 3 (2008–2015)

- No additional change in capability.

5. Increased Surveillance Area Coverage, Air Traffic Services, En Route/Cruise

Figure D-17 shows Phase 2 of this capability.

Phase 1 (1998–2002)

- No change in capability.

Phase 2 (2003–2007)

- Controllers receive satellite-based position reports. Dependent surveillance ground stations extend the range of surveillance coverage.
- Enhanced en route radar coverage provides en route service providers with data from existing terminal secondary radars used to supplement the en route surveillance coverage.

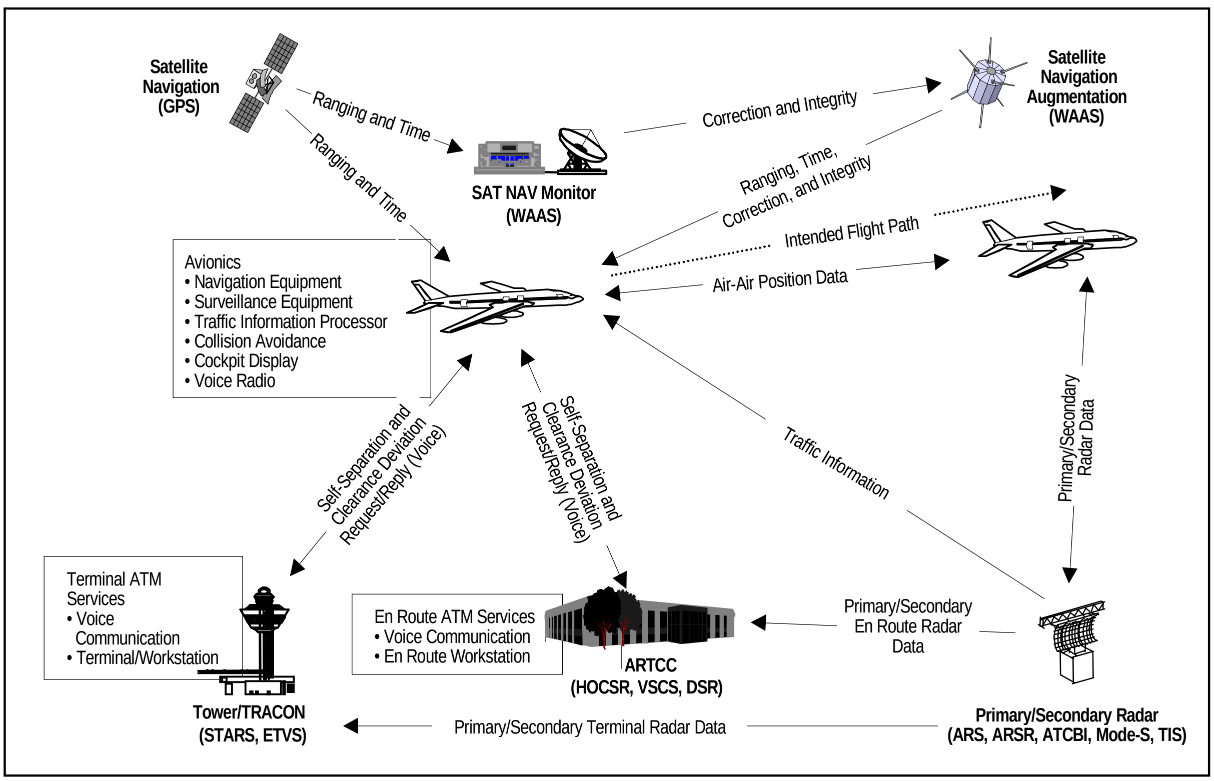

Figure D-16. Increased Self-Separation by Properly Equipped Aircraft, Air Traffic Services, NAS-Wide, Phase 1 (1998–2002)

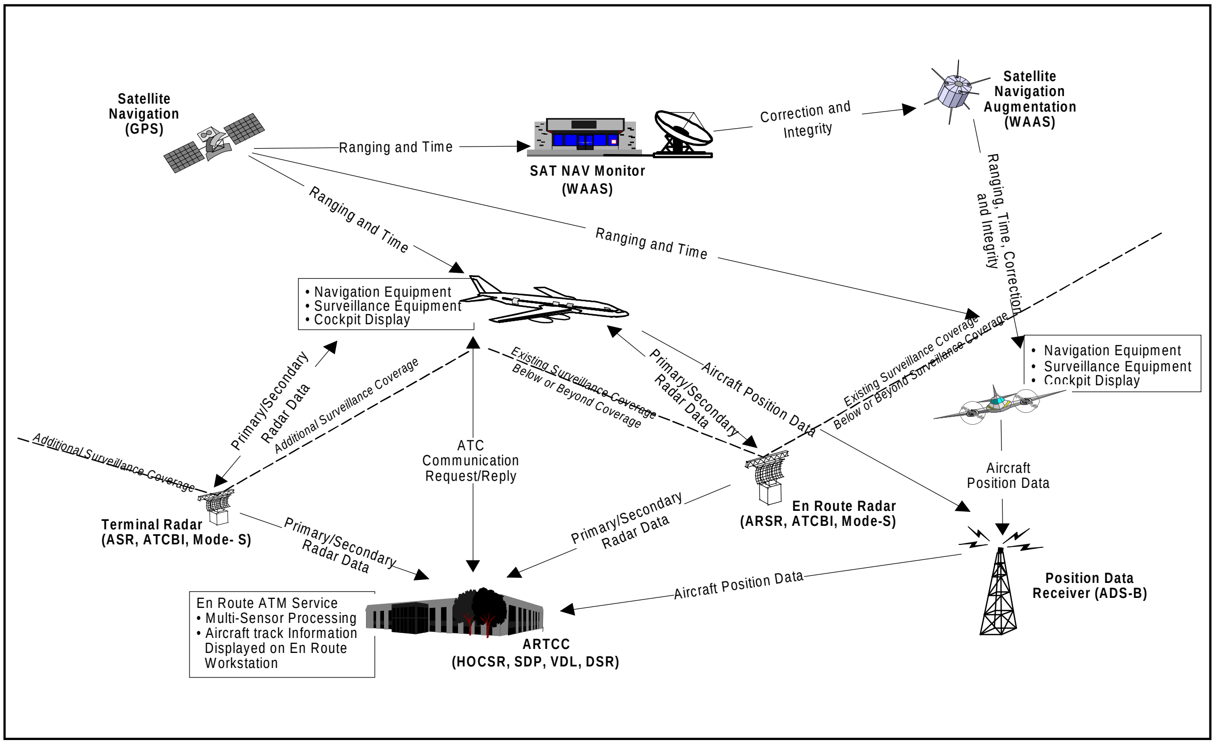

Figure D-17. Increased Surveillance Area Coverage, Air Traffic Services, En Route/Cruise, Phase 2 (2003–2007)

- ADS-B gap-filler provides en route service providers with expanded ability to offer separation services in remote areas not currently covered by radar by providing service providers the ability to receive aircraft position broadcasts.
- The en route automation system will be enhanced to fuse multisensor track data display into a single integrated target on the en route service provider's workstation.

Phase 3 (2008–2015)

No additional change in capability.

5. Increased Surveillance Area Coverage, Air Traffic Services, Oceanic

Figure D-18 shows Phase 2 of this capability.

Phase 1 (1998-2002)

- No change in capability.

Phase 2 (2003-2007)

- Oceanic surveillance via ADS-A (addressable) provides oceanic service providers more timely and more accurate position information about oceanic aircraft.
- ADS will provide surveillance capability in oceanic airspace. ADS-A position reports received from aircraft in oceanic airspace are used to monitor aircraft trajectory from the ground. ADS-A provides position reports generated from the Future Air Navigation System (FANS)-1A- or aeronautical telecommunications network (ATN)-equipped aircraft via satellite communications (SATCOM), high frequency data link (HFDL), or other subnetworks. This gives controllers more timely and accurate position information about oceanic aircraft.
- Coordination between pilots and oceanic controllers is provided by a commercial communications service provider. For aircraft beyond the range of land-based VHF radio communications, the information transfer is by satellite or HF radio.
- ADS increases safety by enhancing situational awareness. It increases capacity by enabling reduced separation of traffic in oceanic airspace by providing controllers more accurate position and intent information about specific aircraft. Flexibility is improved by

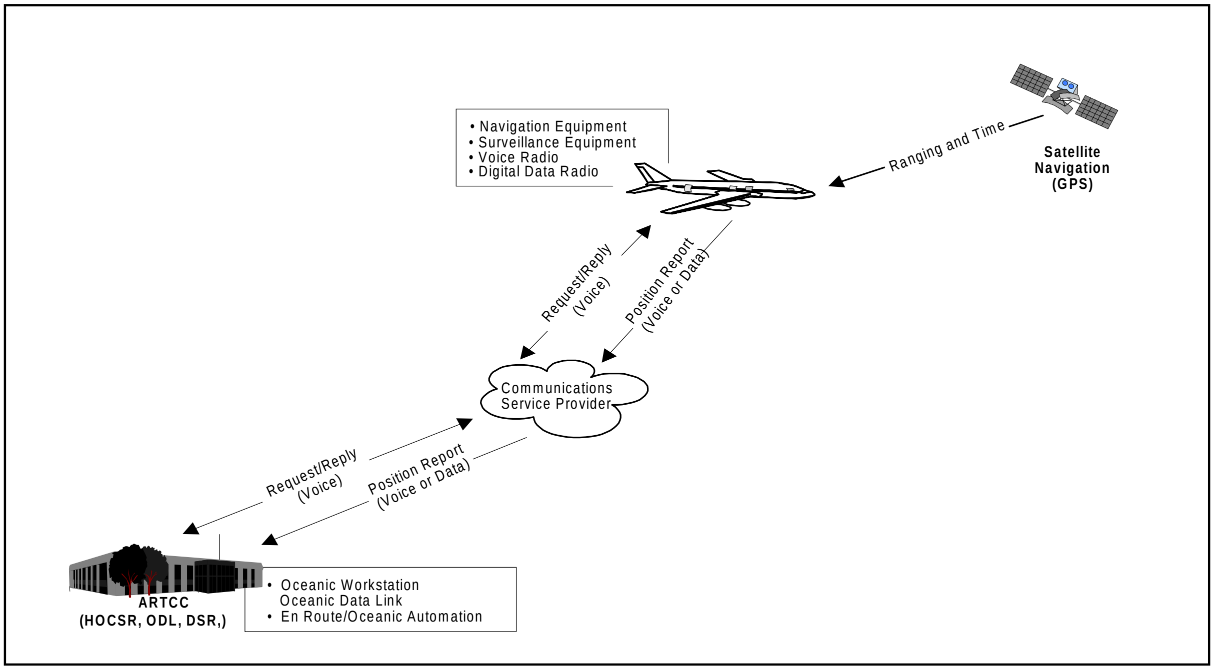

Figure D-18. Increased Surveillance Area Coverage, Air Traffic Services, Oceanic, Phase 2 (2003–2007)

better equipping the oceanic service provider to accommodate flight plan changes in-flight, such as requests for faster aircraft to pass slower aircraft.

Phase 3 (2008-2015)

- No additional change in capability.

6. Increased Digital Voice and Data Communication Among Service Providers and Pilots, Air Traffic Services, Tower/Airport Surface

Figures D-19 and -20 show Phases 1 and 2, respectively, of this capability.

Phase 1 (1998–2002)

- Limited terminal information (e.g., predeparture clearance (PDC), automated terminal information system (ATIS)) is delivered via data link to aircraft on the surface through a data communications service provider.
- VHF/UHF voice continues to be the primary means of communication.

Phase 2 (2003–2007)

- Predeparture clearance and ATIS terminal information is provided to the pilot via service provider data link at an expanded number of airports. This allows a specific set of data to be transmitted from the tower service provider to aircraft.

Phase 3 (2008–2015)

- No additional change in capability.

6. Increased Digital Voice and Data Communications Among Service Providers and Pilots, Air Traffic Services, En Route/Cruise

Figures D-21, -22, and -23 show Phases 1, 2, and 3, respectively, of this capability.

Phase 1 (1998–2002)

- Initial applications of controller-pilot data link (CPDLC Build 1) are limited to less complex and less safety-critical data link functions, such as initial contact, transfer of communications, predefined controller messages, and altimeter setting messages. Communications services are provided by a communications service provider.
- CPDLC Build 1A provides for national deployment of a limited set (18) of critical data link messages.
- Weather data collected in-flight by aircraft equipped with the Meteorological Data Collection and Reporting System (MDCRS) are downlinked via a communications service provider and used for weather forecasting.

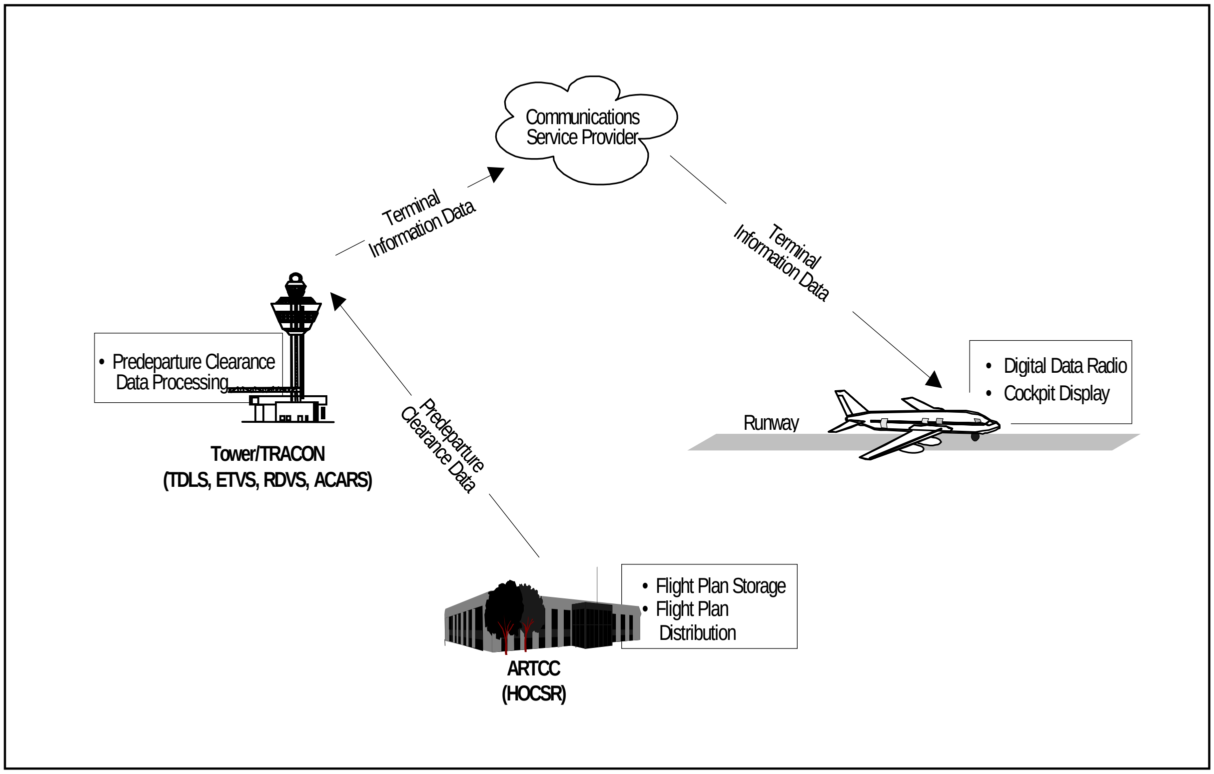

Figure D-19. Increased Digital Voice and Data Communications Among Service Providers and Pilots, Air Traffic Services, Tower/Airport Surface, Phase 1 (1998–2002)

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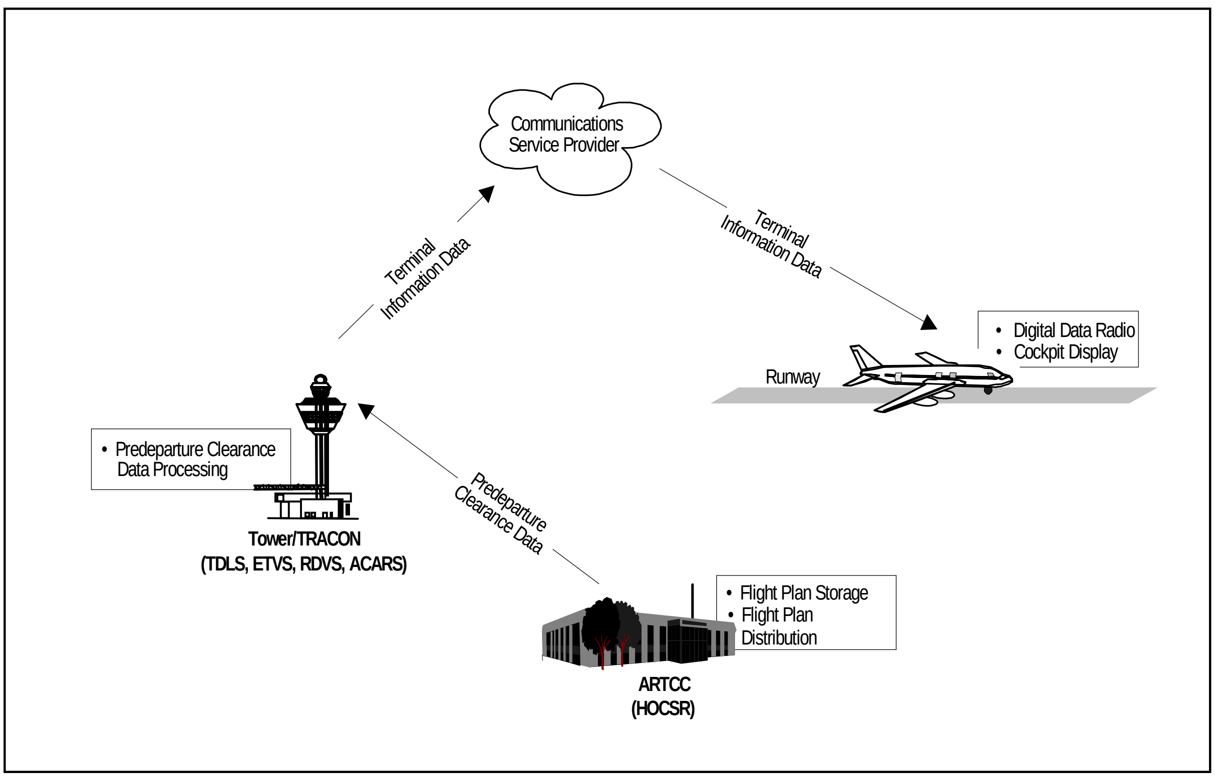

Figure D-20. Increased Digital Voice and Data Communications Among Service Providers and Pilots, Air Traffic Services, Tower/Airport Surface, Phase 2 (2003–2007)

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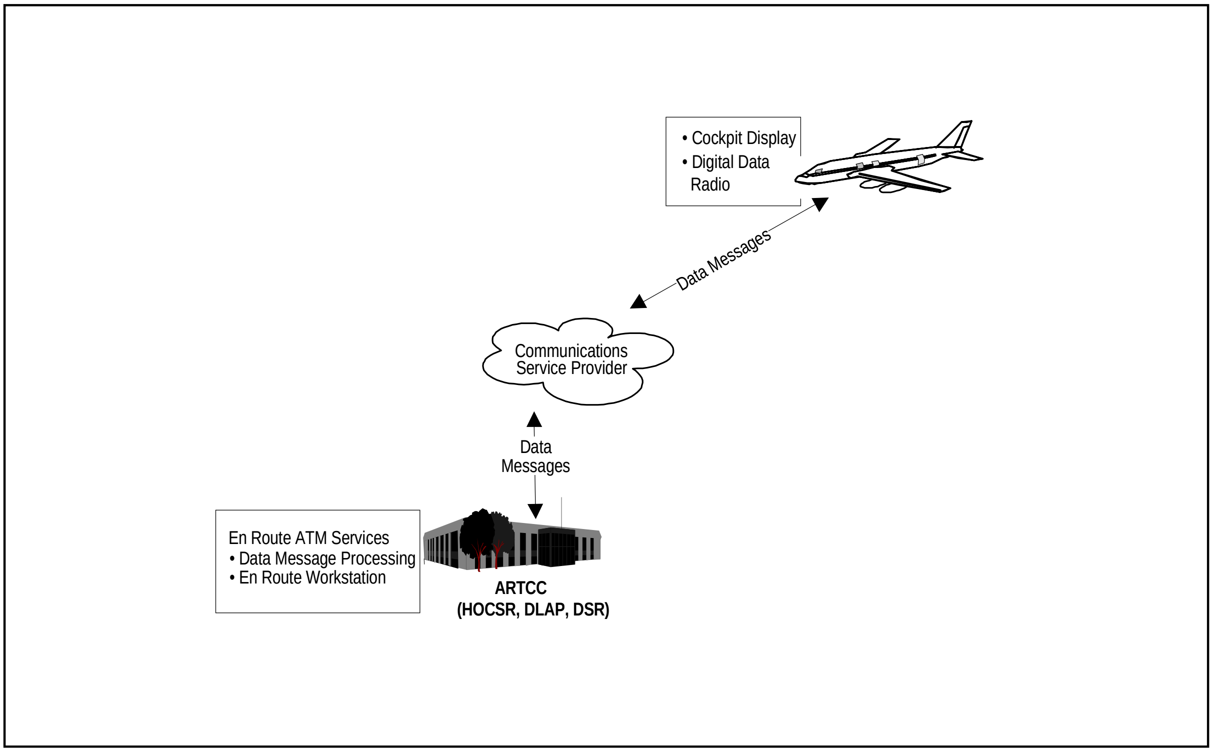

Figure D-21. Increased Digital Voice and Data Communications Among Service Providers and Pilots, Air Traffic Services, En Route/Cruise, Phase 1 (1998–2002)

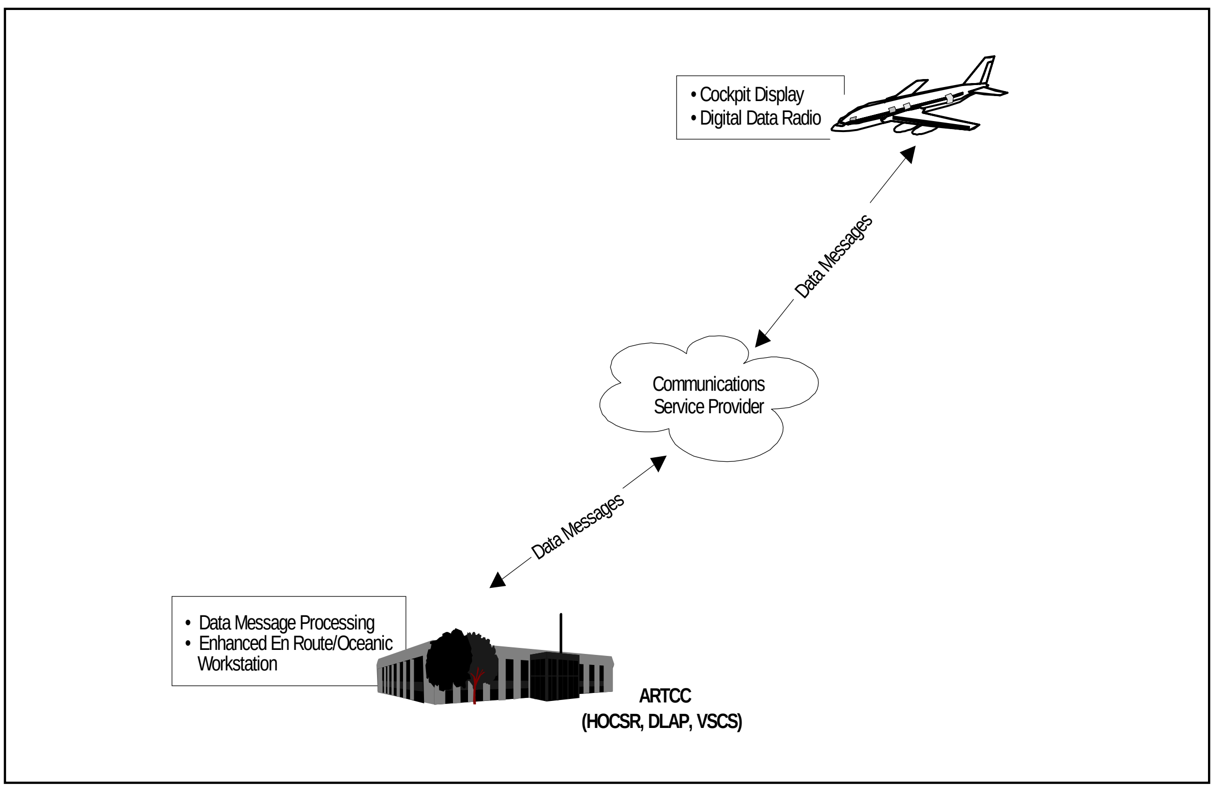

Figure D-22. Increased Digital Voice and Data Communications Among Service Providers and Pilots, Air Traffic Services, En Route/Cruise, Phase 2 (2003–2007)

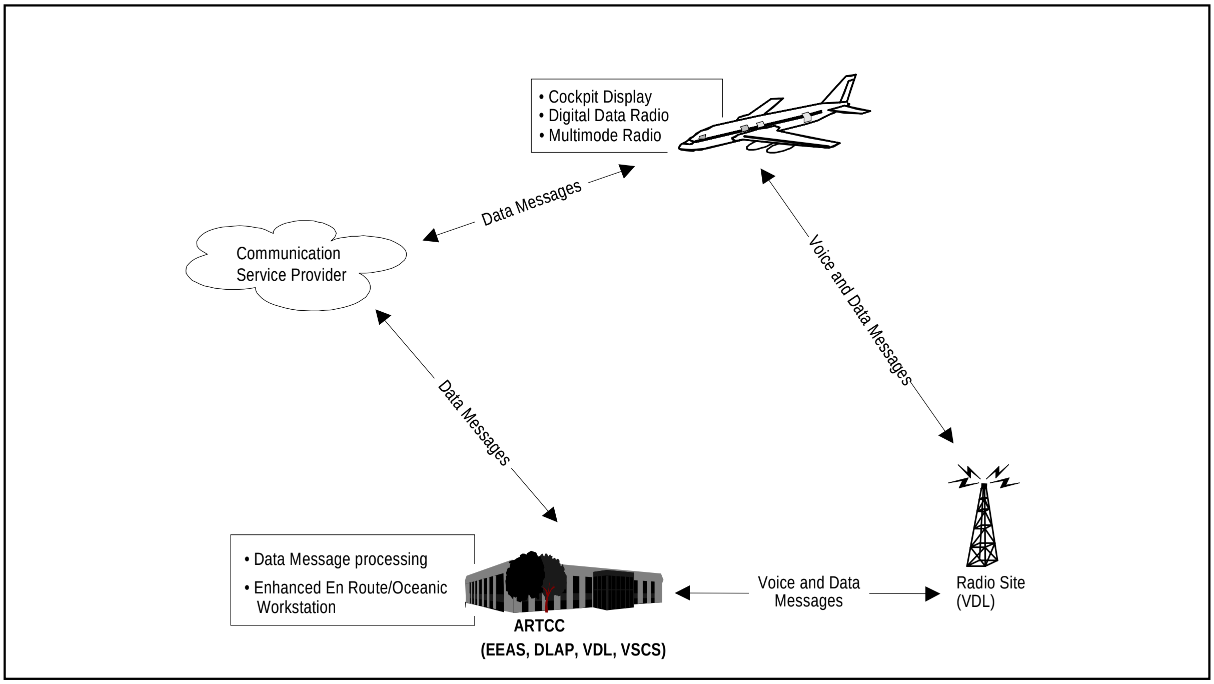

Figure D-23. Increased Digital Voice and Data Communications Among Service Providers and Pilots, Air Traffic Services, En Route/Cruise, Phase 3 (2008–2015)

Phase 2 (2003–2007)

- ATC data link services (CPDLC Build 2) are expanded to include an ATN-compliant message set via very high frequency digital link (VDL-2).

Phase 3 (2008–2015)

- ATC data link services, including CPDLC services, are expanded. VHF digital link (VDL-3) increases the capacity of data link. The introduction of digitized transmission increases the reliability of the communications links.

6. Increased Digital Voice and Data Communications Between Service Providers and Pilots, Air Traffic Services, Oceanic

Figure D-24 shows Phase 1 of this capability.

Phase 1 (1998–2002)

- Pilots provide voice messages, including position reports, to oceanic service providers through a communications service provider operator.

- A communications service provider provides two-way data link between the pilot and controller.

- Multisector oceanic data link provides controllers and pilots the ability to exchange digital data messages throughout oceanic airspace.

Phase 2 (2003–2007)

- No additional change in capability.

Phase 3 (2008–2015)

- Same functionality as En Route/Cruise.

6. Increased Digital Voice and Data Communications Between Service Providers and Pilots, Air Traffic Services, NAS-Wide

Figure D-25 shows Phase 3 of this capability.

Phase 1 (1998–2002)

- No change in capability.

Phase 2 (2003-2007)

- No change in capability.

Phase 3 (2008-2015)

- Digital voice and data communications between service providers and pilot using CPDLC Build 3 via VDL-Mode 3 increase.

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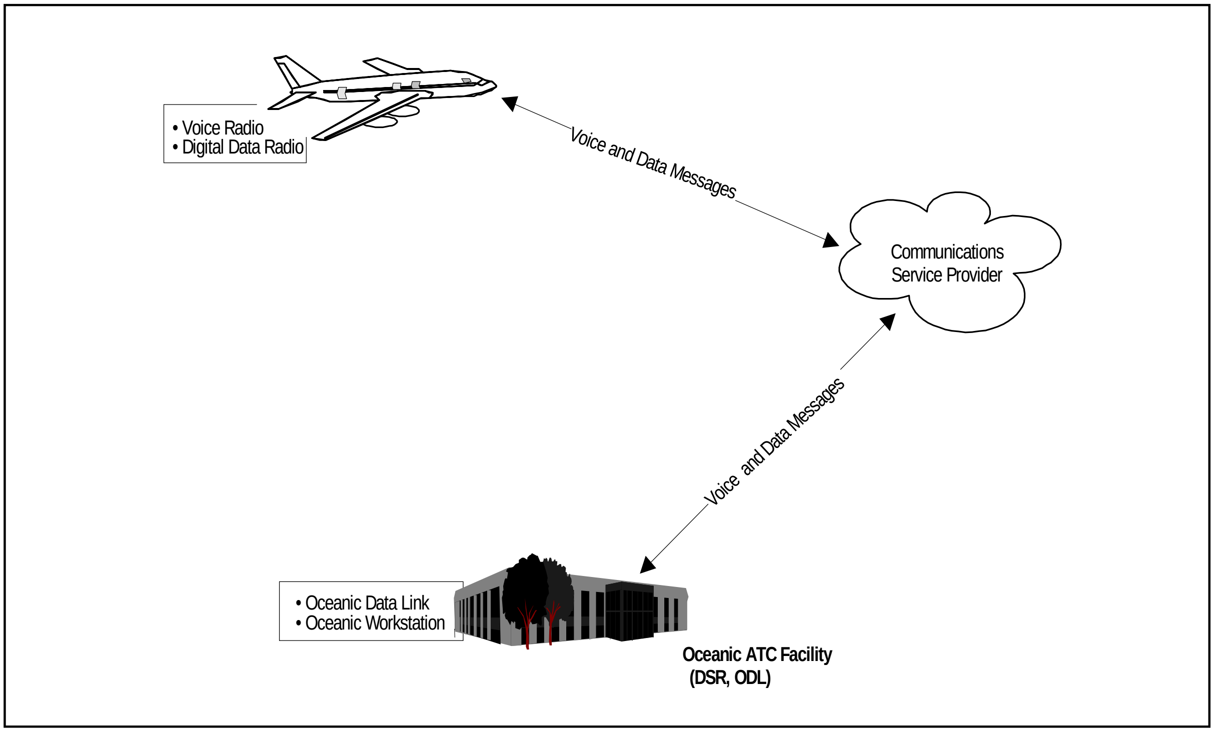

Figure D-24. Increased Digital Voice and Data Communications Between Service Providers and Pilots, Air Traffic Services, Oceanic, Phase 1 (1998–2002)

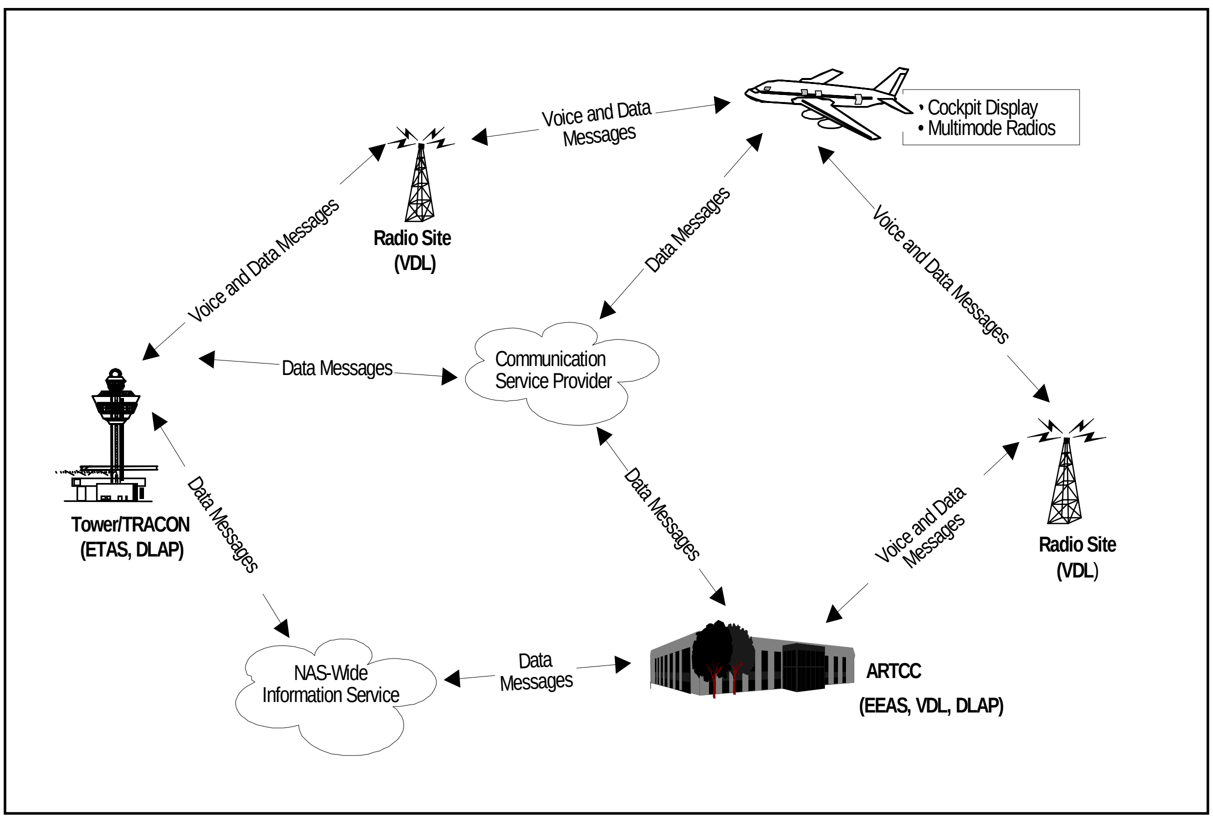

Figure D-25. Increased Digital Voice and Data Communications Between Service Providers and Pilots, Air Traffic Services, NAS-Wide, Phase 3 (2008–2015)

- Service providers and pilots directly exchange digital messages, such as flight information service (FIS) and Traffic Information Service (TIS) information, throughout the NAS using NAS-wide data link.

7. Improved Flight Plan Negotiation, Air Traffic Services, NAS-Wide

Figure D-26 shows Phase 3 of this capability.

Phase 1 (1998–2002)

- No change in capability.

Phase 2 (2003–2007)

- No change in capability.

Phase 3 (2008–2015)

- A new flight object replaces the existing flight plan. The flight object is a 4-dimensional interactive flight profile that is continually monitored and updated throughout an aircraft's active flight. The new flight object contains many more fields of information and conforms to international standards.
- The flight object is activated at aircraft pushback from the departure gate and remains active until engine shutdown at the destination airport.
- The enhanced en route automation system (EEAS) and enhanced terminal automation system (ETAS) use the flight object to automatically approve and monitor diverse departure and arrival paths as well as en route flight trajectories. Flight conformance monitoring, conflict detection, and recommended resolutions are fully automated during this time period.

8. Improved Arrival and Departure Sequencing and Spacing for Tactical Traffic Flow, Air Traffic Services, Arrival/Departure

Figures D-27 and -28 show Phases 1 and 3, respectively, of this capability.

Phase 1 (1998–2002)

- Introduction of metering tools introduces automation to assist en route service providers in feeding aircraft to airport approach controls at a predetermined rate.
- The Final Approach Spacing Tool (FAST) assists service providers in sequencing and spacing aircraft in high-density terminal areas.

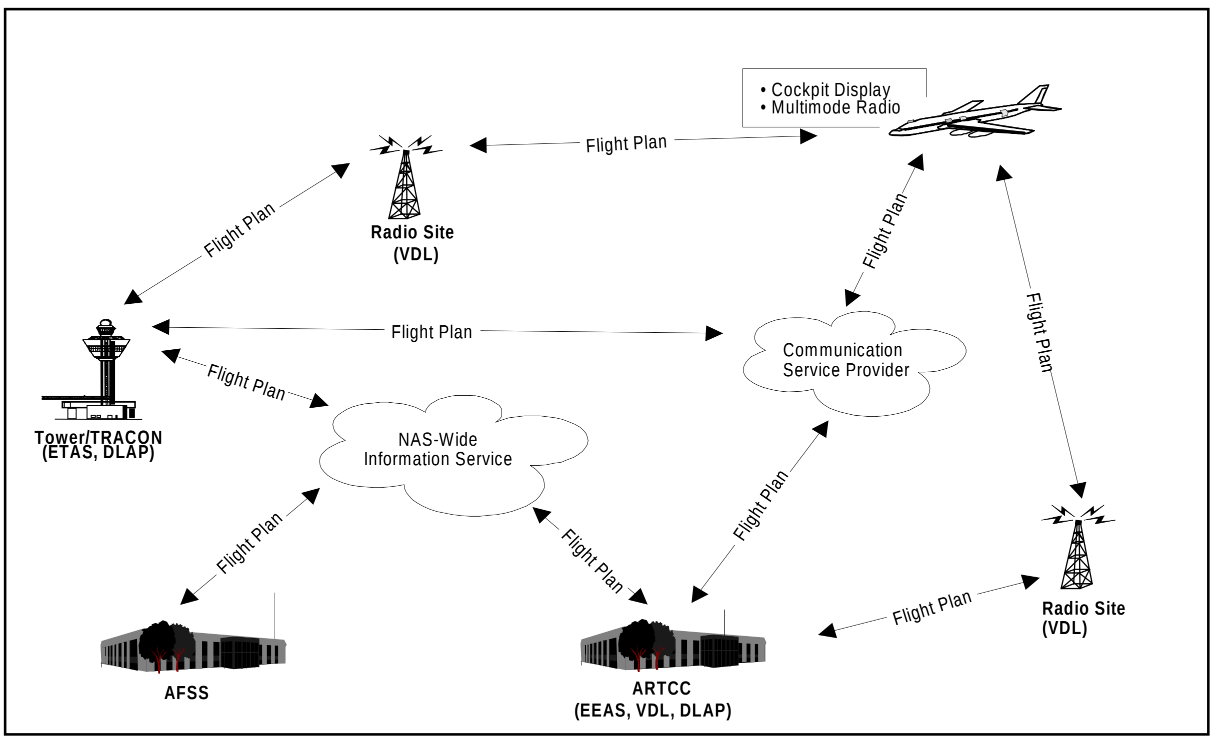

Figure D-26. Improved Flight Plan Negotiation, Air Traffic Services, NAS-Wide, Phase 3 (2008–2015)

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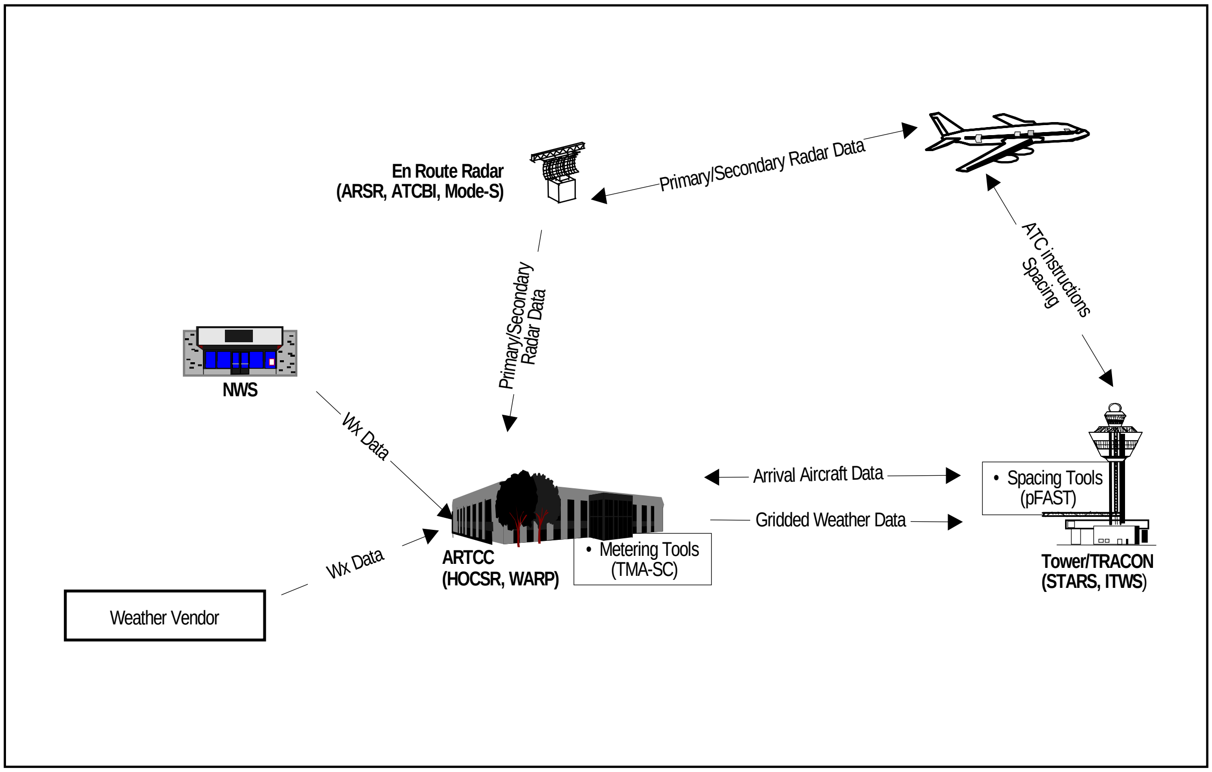

Figure D-27. Improved Arrival and Departure Sequencing and Spacing for Tactical Traffic Flow, Air Traffic Services, Arrival/Departure, Phase 1 (1998–2002)

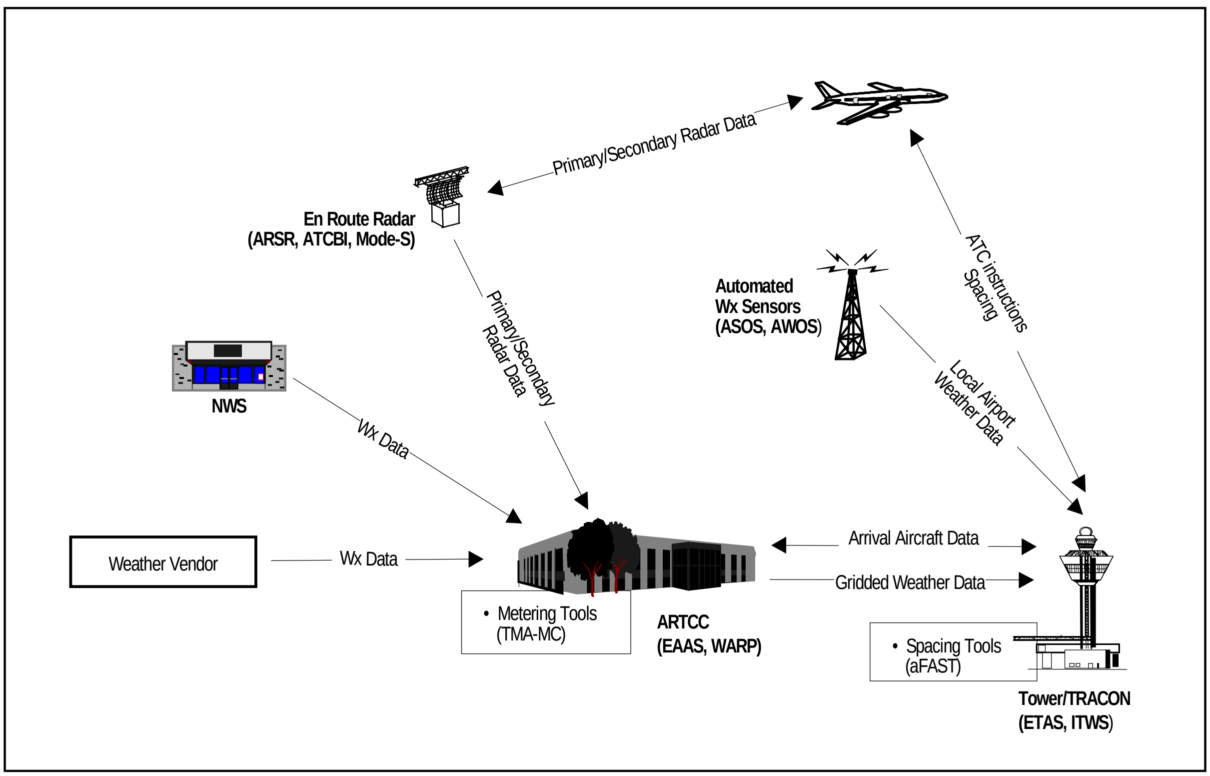

Figure D-28. Improved Arrival and Departure Sequencing and Spacing for Tactical Traffic Flow, Air Traffic Services, Arrival/Departure, Phase 3 (2008–2015)

Phase 2 (2003–2007)

- No additional change in capability.

Phase 3 (2008–2015)

- Enhanced final approach spacing tools incorporate additional parameters (i.e., wake vortex, aircraft performance, user preferences) to fine-tune sequencing and spacing of arriving aircraft.

8. Improved Arrival and Departure Sequencing and Spacing for Tactical Traffic Flow, Air Traffic Services, En Route/Cruise

Figures D-29 and -30, show Phases 1 and 2, respectively, of this capability.

Phase 1 (1998-2002)

- Introduction of metering tools introduces automation to assist en route service providers in feeding aircraft to airport approaches at a predetermined rate.

Phase 2 (2003-2007)

- Air Traffic Management automation tools recommend a course of action to service providers for smoothing traffic flows to maximize airport capacity utilization.
- Multicenter processing of traffic flow increases system capacity utilization.
- Descent advisory tools provide en route service providers recommended tip of "descent points," which makes maximum use of aircraft descent profiles.

Phase 3 (2008-2015)

- No additional change in capability.

9. Increased Flexibility in Flying User-Preferred Routes, Air Traffic Services, En Route/ Cruise

Figures D-31, -32, and -33 show Phases 1, 2, and 3, respectively, of this capability.

Phase 1 (1998–2002)

- User request evaluation tool (URET) is available at several facilities to assist controllers in predicting aircraft-to-aircraft conflicts. The service provider's resolution of detected conflict is communicated to the cockpit via the existing VHF/UHF radio system.

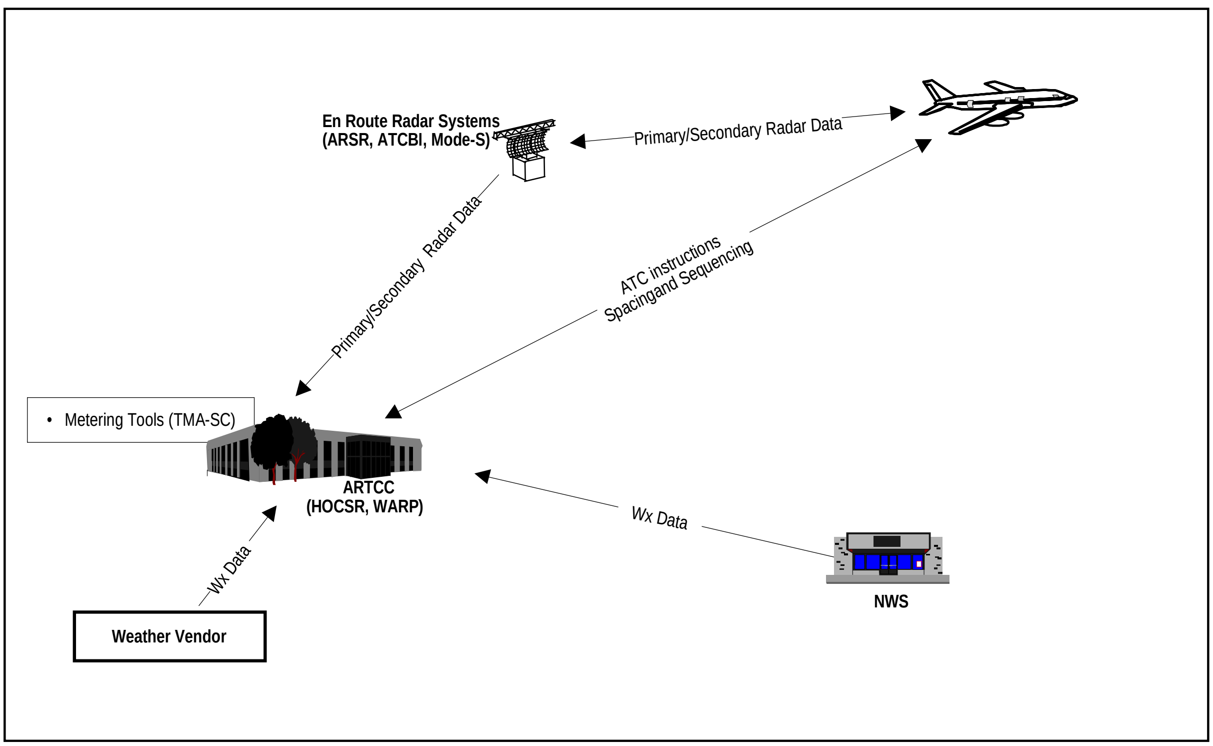

Figure D-29. Improved Arrival and Departure Sequencing and Spacing for Tactical Traffic Flow, Air Traffic Services, En Route/Cruise, Phase 1 (1998–2002)

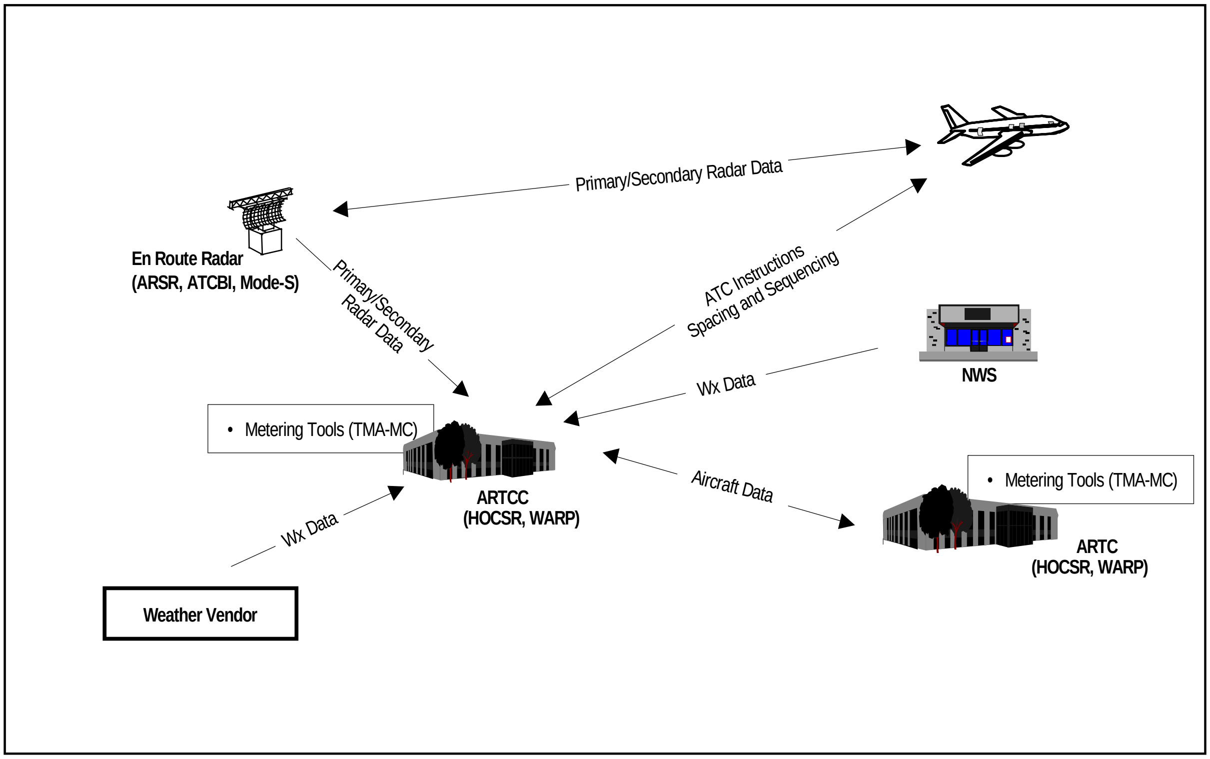

Figure D-30. Improved Arrival and Departure Sequencing and Spacing for Tactical Traffic Flow, Air Traffic Services, En Route/Cruise, Phase 2 (2003–2007)

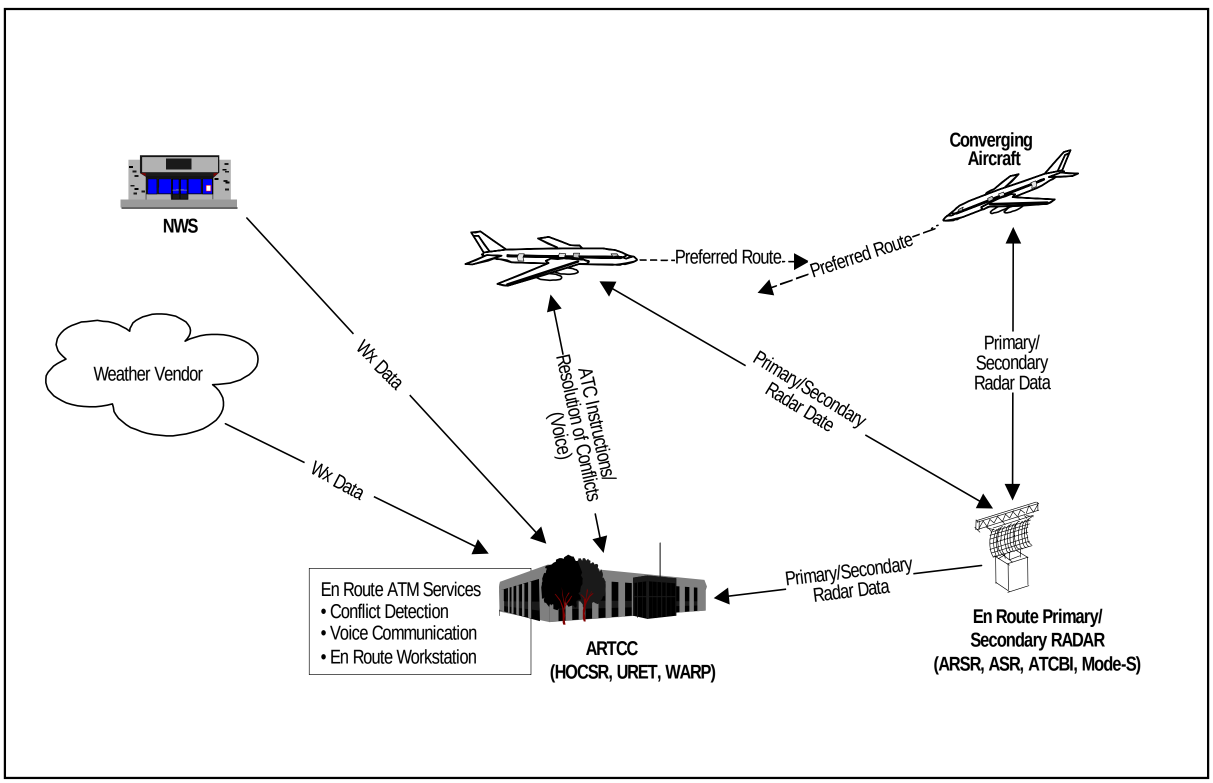

Figure D-31. Increased Flexibility in Flying User-Preferred Routes, Air Traffic Services, En Route/Cruise, Phase 1 (1998–2002)

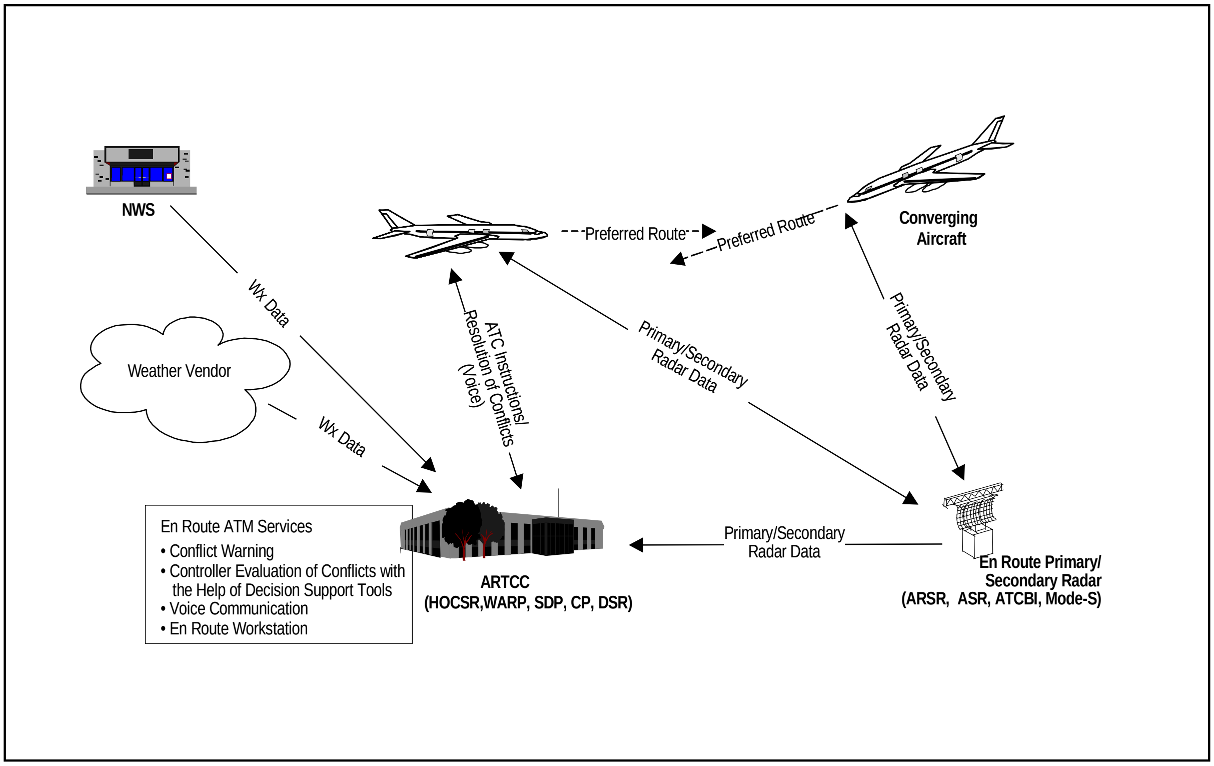

Figure D-32. Increased Flexibility in Flying User-Preferred Routes, Air Traffic Services, En Route/Cruise, Phase 2 (2003–2007)

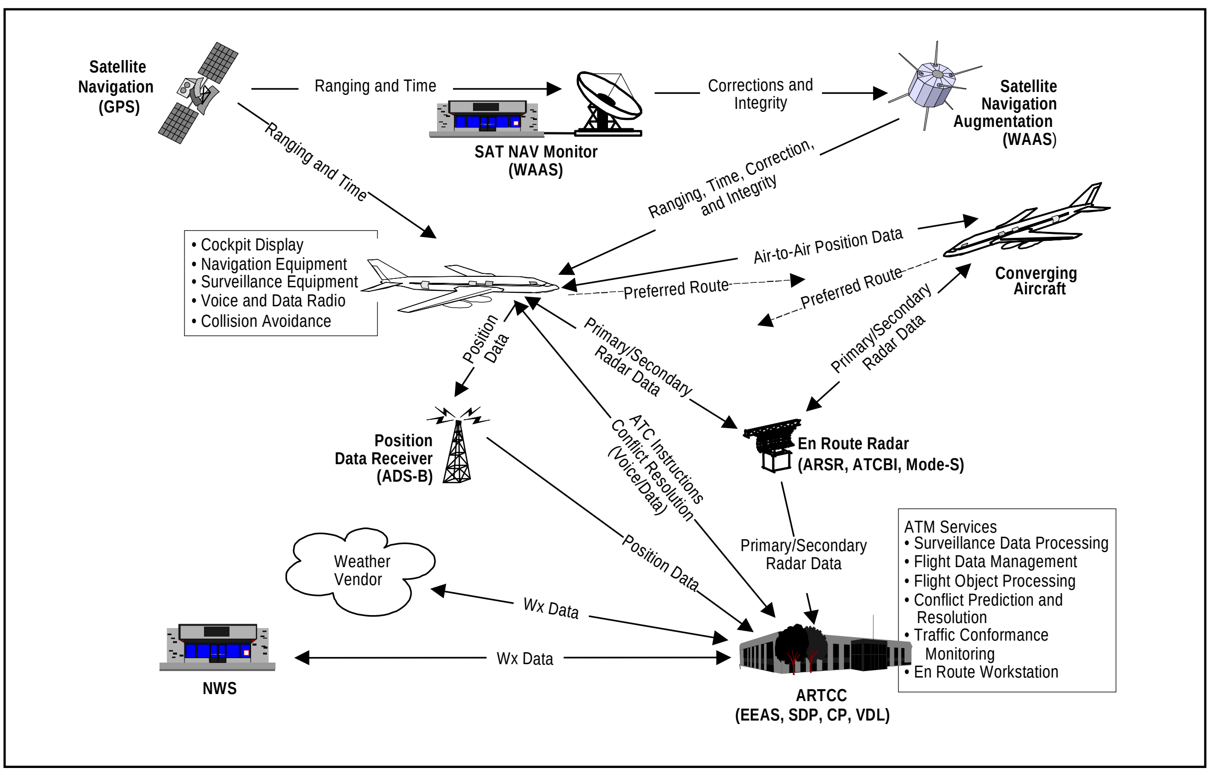

Figure D-33. Increased Flexibility in Flying User-Preferred Routes, Air Traffic Services, En Route/Cruise, Phase 3 (2008–2015)

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Phase 2 (2003–2007)

- The ability to predict potential flight conflicts is enhanced by a limited national deployment version of conflict probe to selected sites.

Phase 3 (2008–2015)

- Flight object processing, integrated data link, and ATC/traffic flow management (TFM) decision support system (DSS) applications evolve and are integrated to assist controllers with conflict prediction and recommend actions to avoid the conflict. Conflict probe will be enhanced and deployed nationwide as a conflict probe with multicenter metering and integrated into the en route radar position workstation. The improved conflict probe provides better conflict resolution for evaluation by service providers. Implementation of flight object processing and the NAS-wide information network allows end-to-end checking of aircraft flight paths.

10. Increased Airspace Capacity, Air Traffic Services, Oceanic

Figures D-34 and -35 show Phases 1 and 2, respectively, of this capability.

Phase 1 (1998–2002)

- Reduced vertical separation minimum (RVSM) will allow increased airspace capacity, increased use of optimum altitude profile and increased flexibility of strategic and tactical control.

- RVSM-enabling capabilities involve aircraft avionics (enhanced altimeters, Mode-C transponder, altitude alert system, and automatic altitude hold system).

- Reduction of the separation minima is achieved through improved accuracy and timeliness of ADS-A position reports (from properly equipped aircraft) and enhancements to ground-based automation equipment.

- Air-air position reports provide additional data to enhance pilot awareness of nearby aircraft.

- Addressable automatic dependent surveillance position reports are periodically transmitted to the oceanic automation system via a communications service provider communications link.

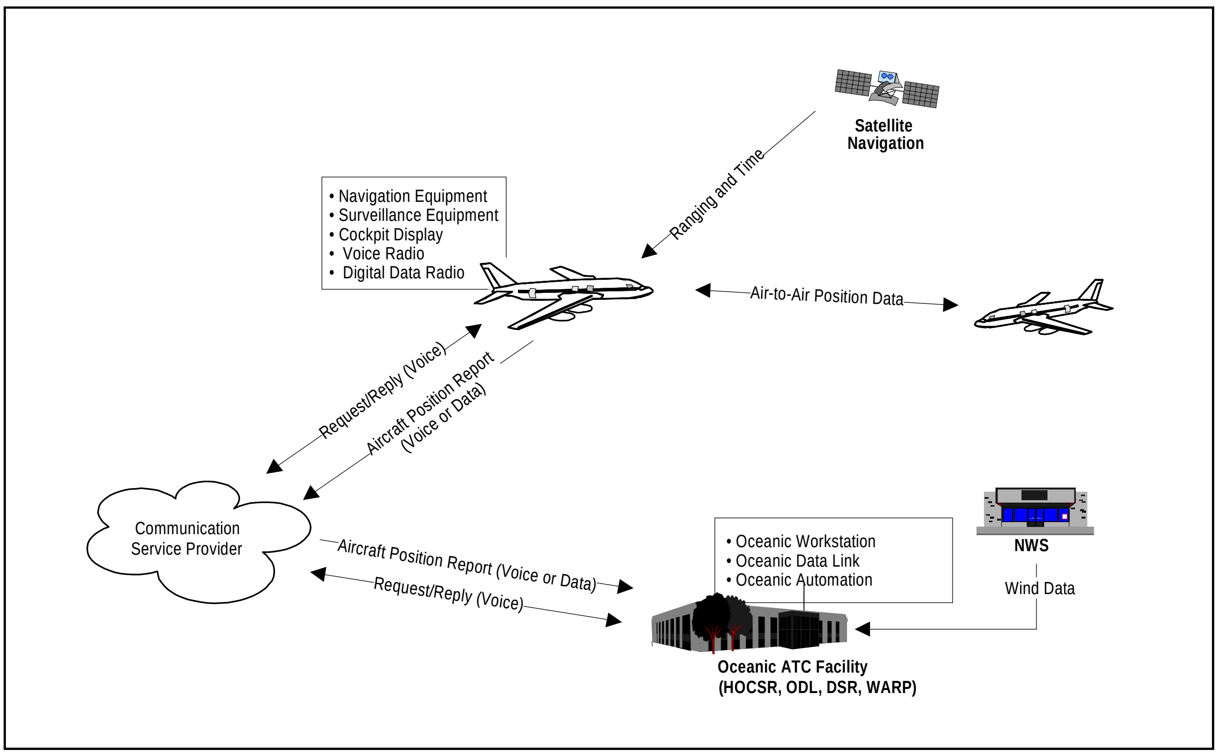

Figure D-34. Increased Airspace Capacity, Air Traffic Services, Oceanic, Phase 1 (1998–2002)

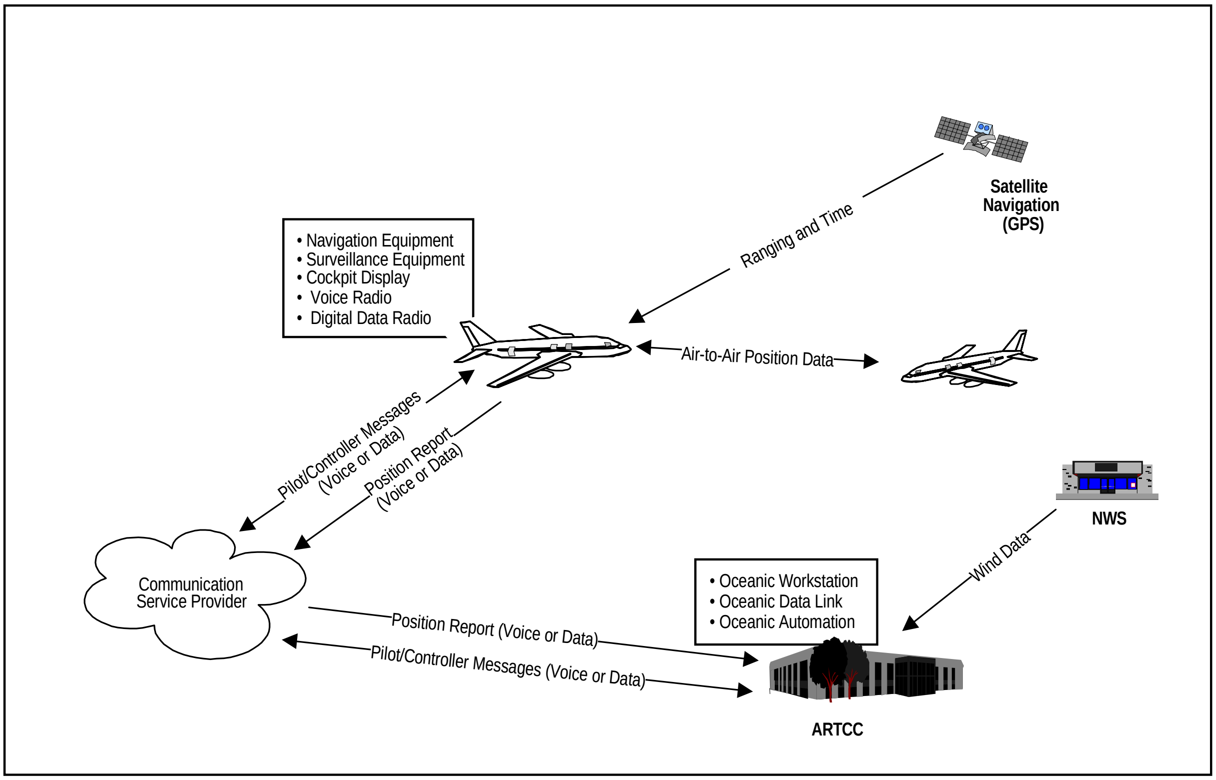

Figure D-35. Increased Airspace Capacity, Air Traffic Services, Oceanic, Phase 2 (2003–2007)

- Oceanic automation uses updated wind data to identify optimal tracks, while projecting aircraft movement to identify airspace competition and availability.

Phase 2 (2003–2007)

- Two-controller access provides oceanic service providers with the capability to distribute traffic workload and handling data-link equipped aircraft during peak traffic times.
- Reduced horizontal separation minimum to 50 lateral, 50 longitudinal will reduce crossing traffic complexity as well as create the potential for more optimum routings to reduce flight time and fuel consumption.
- 50/50 separation requires direct pilot-controller communication, required navigation performance (RNP)-10, and ADS.

Phase 3 (2008–2015)

- Same functionality as En Route/Cruise.

11. Improved Surface Traffic Management, Air Traffic Services, Tower/Airport Surface

Figures D-36,- 37, and -38 show Phases 1, 2, and 3, respectively, of this capability.

Phase 1 (1998–2002)

- As an aircraft approaches the runway, tracks from beacon radar returns are merged with surface radar tracks to automatically associate the track with the flight identification. The automation function continues to track the aircraft on the airport surface, displaying its position and identification to ground service providers.
- As an aircraft backs away from the boarding gate, the flight identification and surface surveillance returns are associated. The aircraft is tracked and displayed on a surface surveillance display.
- The surface surveillance function displays a map of the airport on the surface surveillance display to help ground service providers monitor the surface situation.
- Taxiway lights and signs (taxiway markers) provide visual guidance to flight crews on the airport surface.

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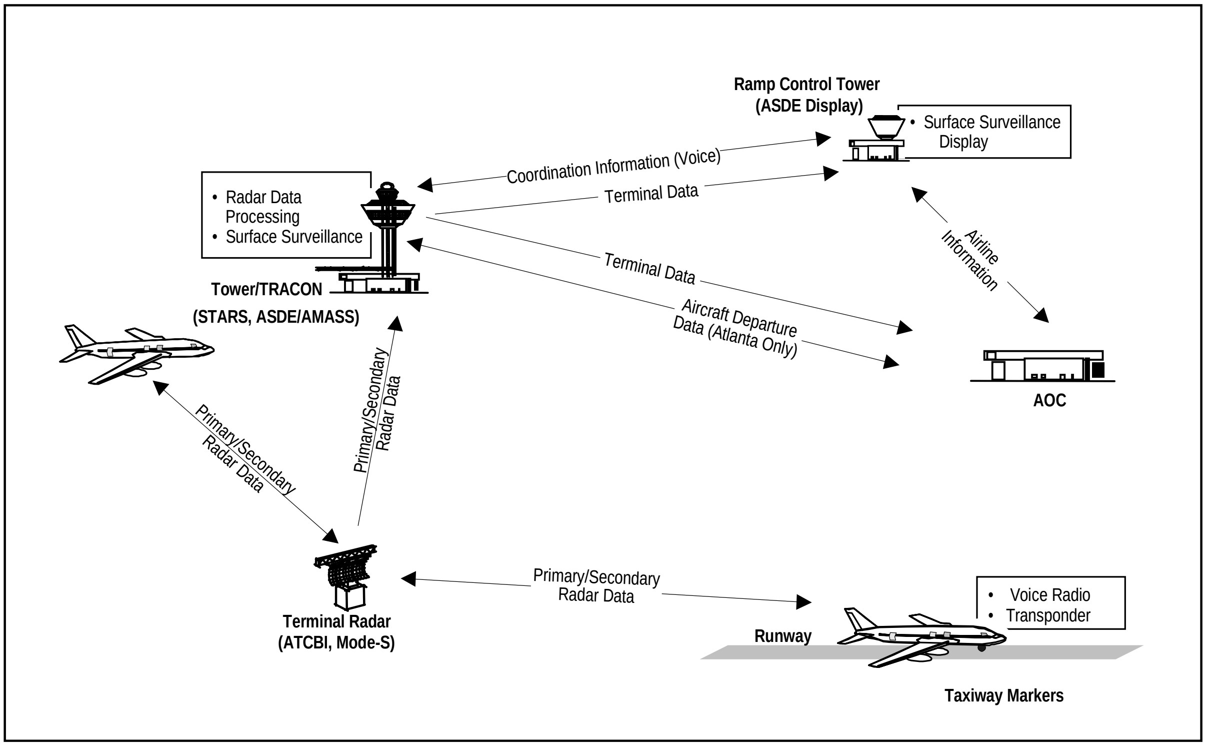

Figure D-36. Improved Surface Traffic Management, Air Traffic Services, Tower/Airport Surface, Phase 1 (1998–2002)

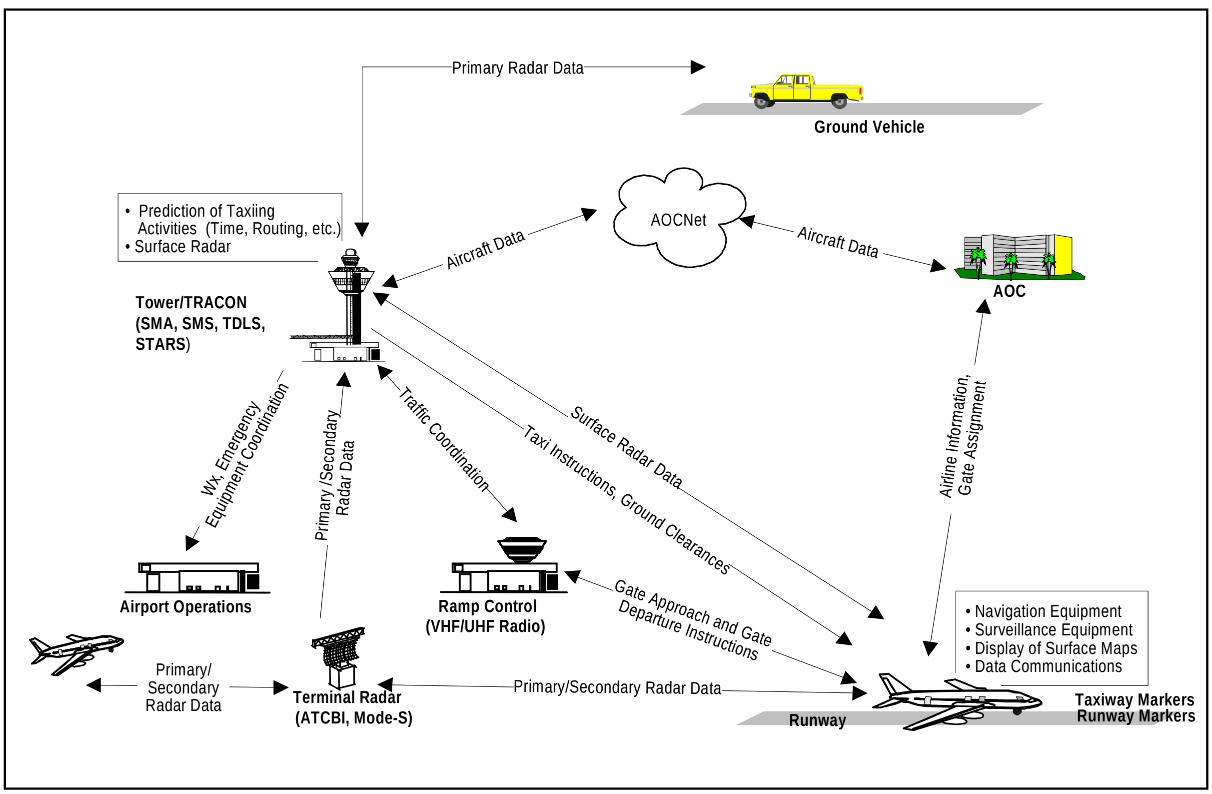

Figure D-37. Improved Surface Traffic Management, Air Traffic Services, Tower/Airport Surface, Phase 2 (2003–2007)

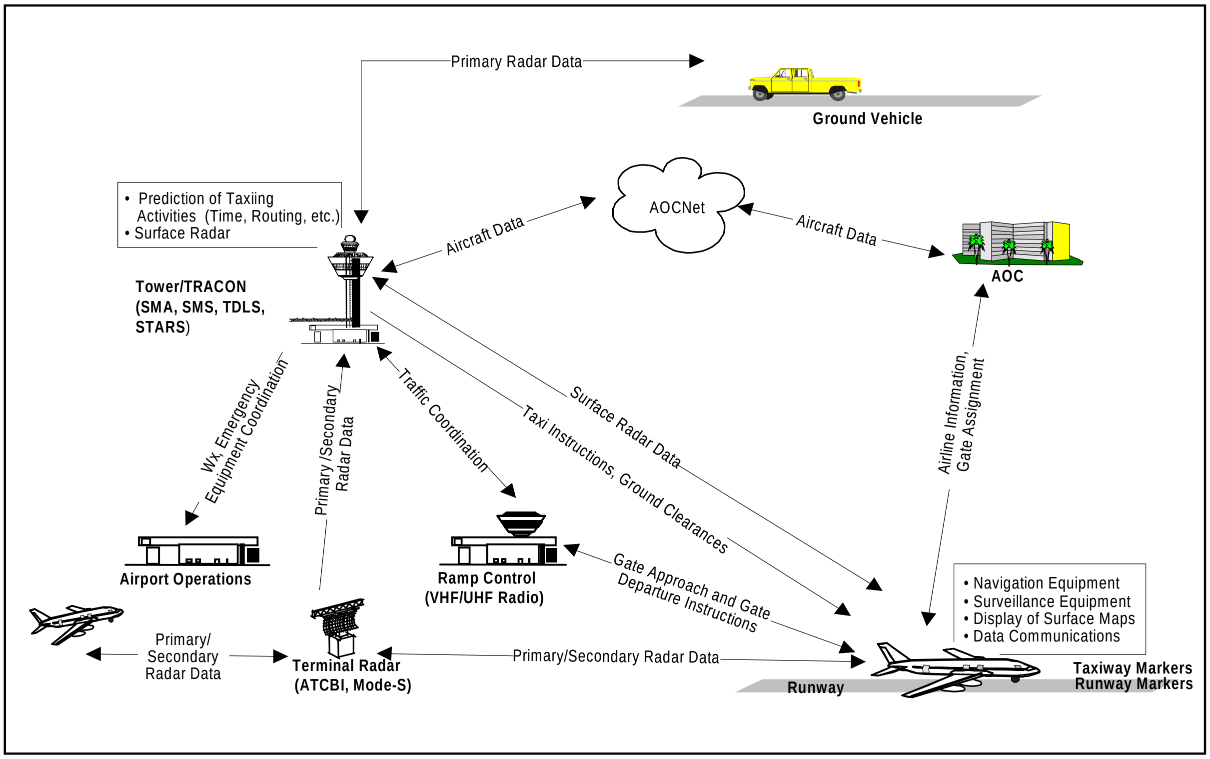

Figure D-38. Improved Surface Traffic Management, Air Traffic Services, Tower/Airport Surface, Phase 3 (2008–2015)

Phase 2 (2003–2007)

- Integrated situation display of airport surface and terminal data assists the service provider in managing the airport area.
- Introducing networking technology in the tower environment significantly decreases the time delay for delivery of critical traffic information to the service providers, airline personnel, and airport operations.

Phase 3 (2008–2015)

- Introducing global positioning local augmentation increases the accuracy of the position data from both surface vehicular and aircraft traffic. The additional data are provided to improve the situational awareness of service providers and pilots. Data fusion further enhances the accuracy of position data presented to the service provider.
- Introducing airport surface maps in the cockpit provides additional data to assist flight crews in improving their situational awareness.

12. Increased Low-Altitude Direct Routes, Air Traffic Services, NAS-Wide

Figures D-39 and -40 show Phases 1 and 2, respectively, of this capability.

Phase 1 (1998–2002)

- Aircraft will navigate direct using WAAS, and its position will be derived, where possible, from en route surveillance radar.

Phase 2 (2003–2007)

- Aircraft will navigate direct using WAAS, and its position will be determined by ATC from either the en route surveillance radar or a terminal radar system.
- Aircraft will navigate direct using WAAS, and its position will be determined from ADS-B.

Phase 3 (2008–2015)

- No additional change in capability.

13. Increased Availability of Aeronautical Information to Service Providers and NAS Users, Air Traffic Services, NAS-Wide

Figure D-41 shows Phase 3 of this capability.

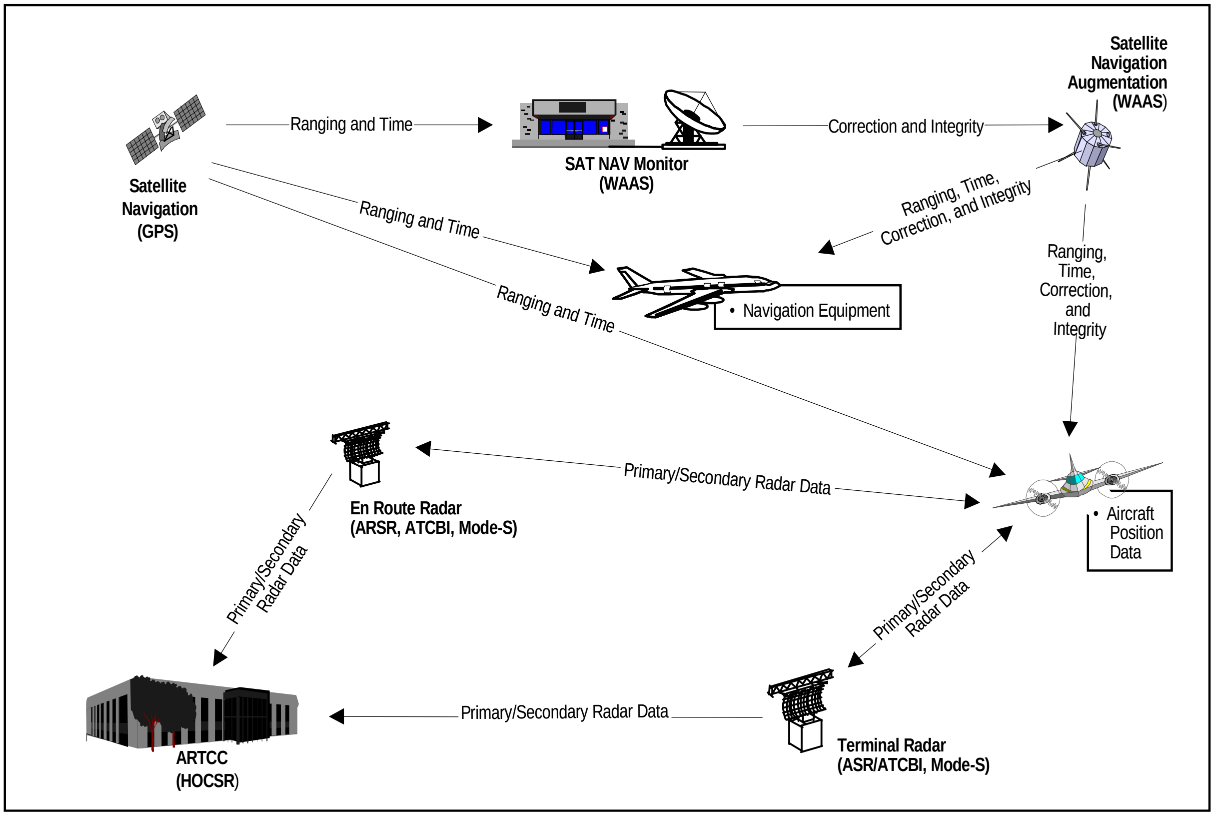

Figure D-39. Increased Low-Altitude Direct Routes, Air Traffic Services, NAS-Wide, Phase 1 (1998–2002)

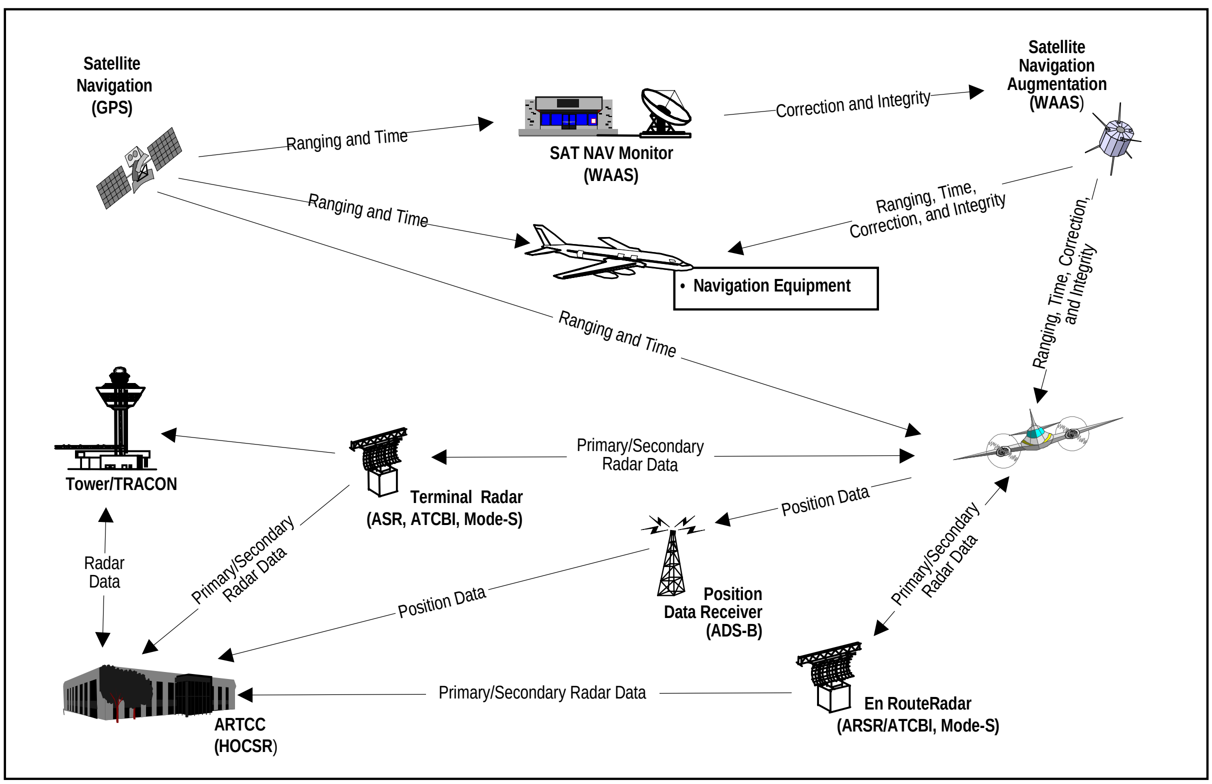

Figure D-40. Increased Low-Altitude Direct Routes, Air Traffic Services, NAS-Wide, Phase 2 (2003–2007)

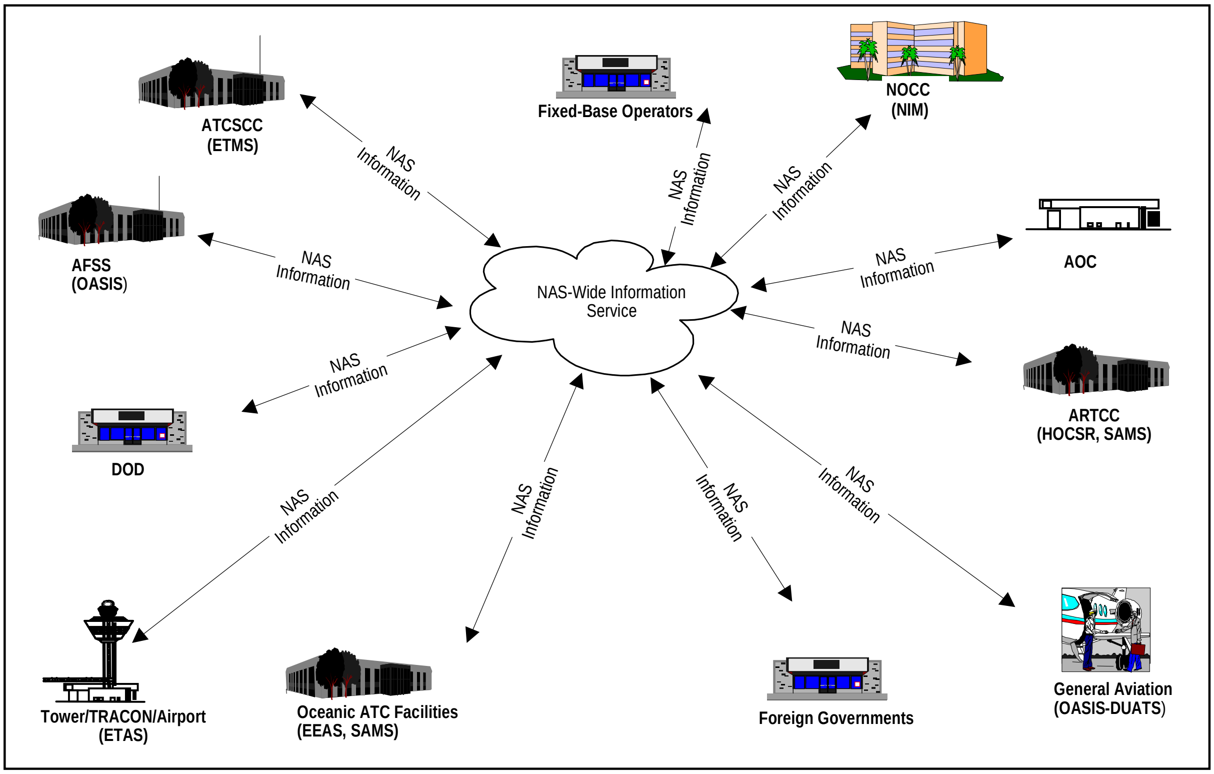

Figure D-41. Increased Availability of Aeronautical Information to Service Providers and NAS Users, Air Traffic Services, NAS-Wide, Phase 3 (2008–2015)

Phase 1 (1998–2002)

- No change in capability.

Phase 2 (2003–2007)

- No change in capability.

Phase 3 (2008–2015)

- A NAS-wide information-sharing system is established to provide real-time exchange of NAS data. The data include NAS operational and maintenance status, weather, FAA facility status, and AOC and DOD operations information.

- Information systems security measures are in place to ensure data integrity.

14. Improved Collaborative Decisionmaking Between Service Providers and NAS Users for Strategic Planning, NAS Management Services, Traffic Management

Figures D-42, -43, and -44 show Phases 1, 2, and 3, respectively, of this capability.

Phase 1 (1998–2002)

- The introduction and integration of traffic management tools significantly enhance the collaborative decisionmaking process.

- As ATC automation tools begin to share strategic traffic flow messages, the collaborative decisionmaking process will mature. The dedicated airline operations network provides schedule information to the ATCSCC. This information can be coordinated with ARTCC and major terminal facilities in real time.

Phase 2 (2003–2007)

- Flight plan evaluation is based on a real-time exchange of data via a local area network (LAN) and a wide area network (WAN) that will provide a rapid two-way exchange of aeronautical information used by strategic planners in the FAA as well as the airlines, private industry, and the DOD.

- NAS flight operations are monitored for real-time compliance, and system-level impact assessments are readily available to all system users.

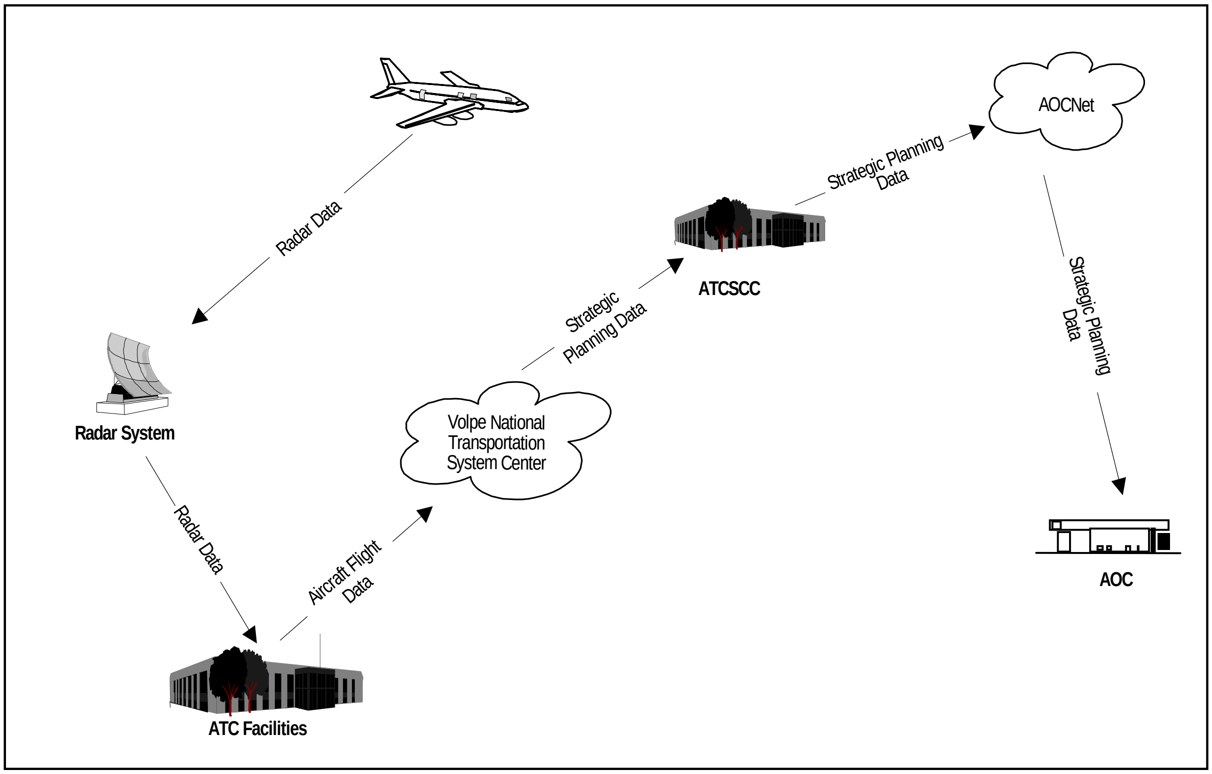

Figure D-42. Improved Collaborative Decisionmaking Between Service Providers and NAS Users for Strategic Planning, NAS Management Services, Traffic Management, Phase 1 (1998–2002)

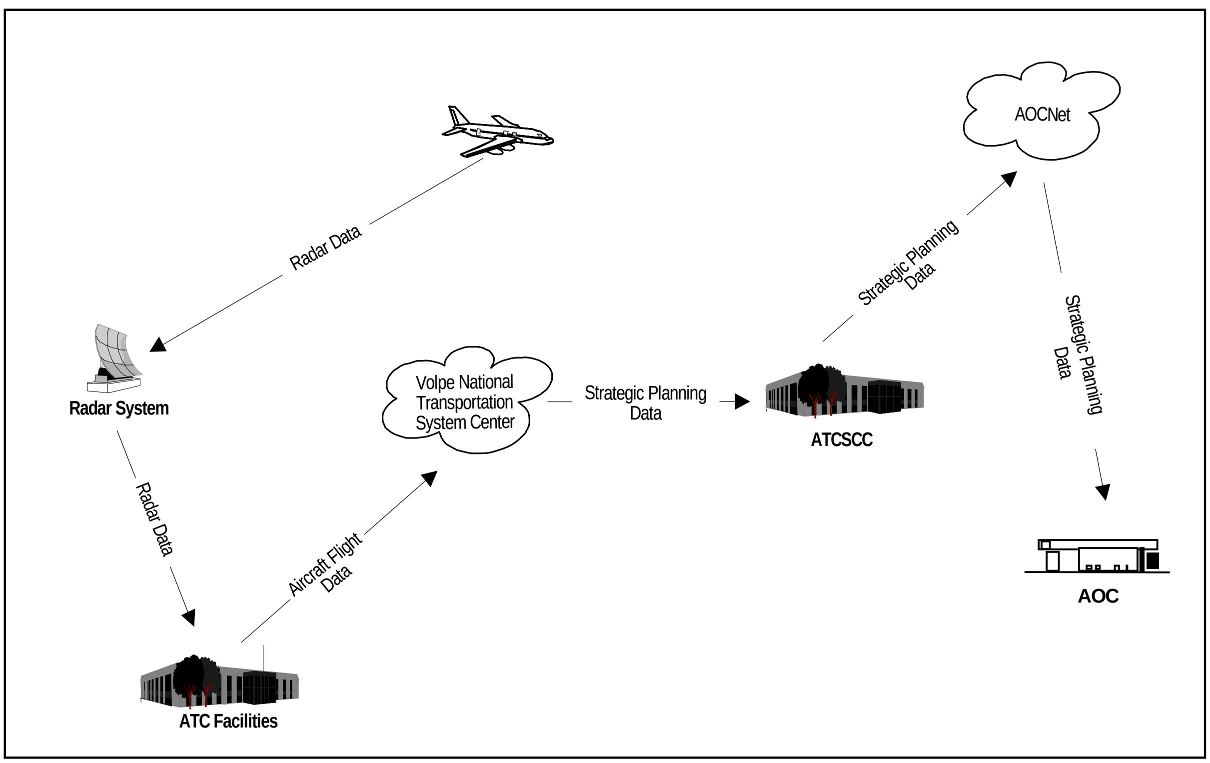

Figure D-43. Improved Collaborative Decisionmaking Between Service Providers and NAS Users for Strategic Planning, NAS Management Services, Traffic Management, Phase 2 (2003–2007)

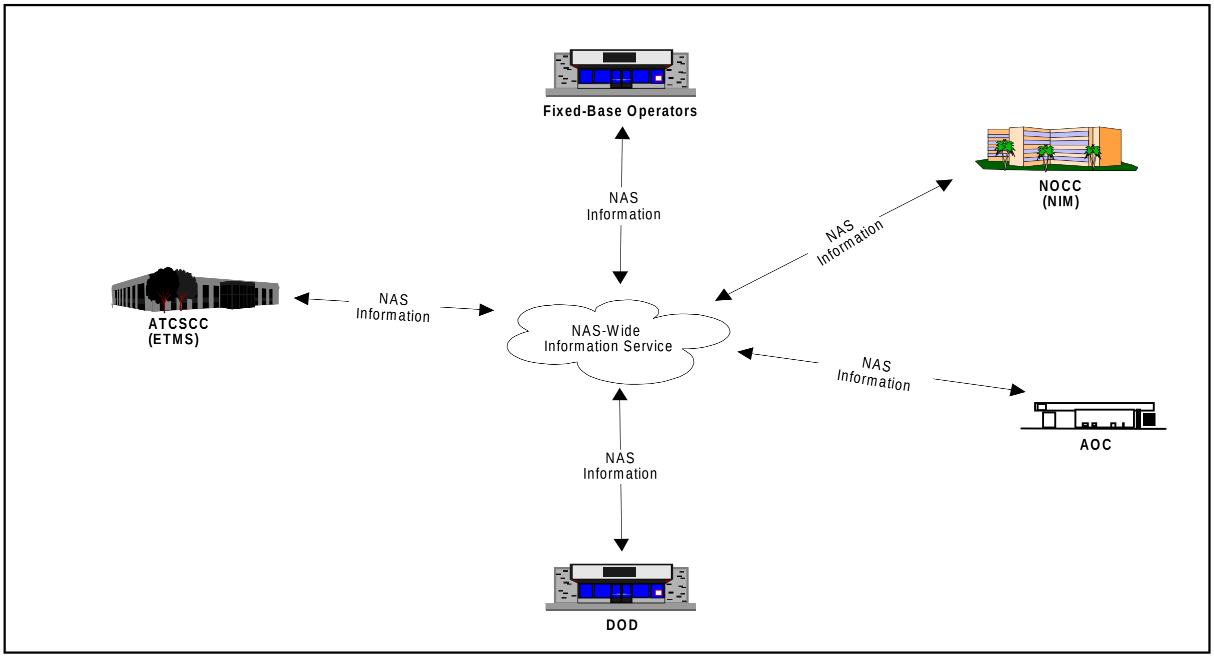

Figure D-44. Improved Collaborative Decisionmaking Between Service Providers and NAS Users, NAS Management Services, Traffic Management, Phase 3 (2008–2015)

- Airline resources effectiveness is increased through closer airline operations center (AOC)/NAS coordination and the ability to evaluate impacts on a fleet basis.

Phase 3 (2008–2015)

- Systemwide CDM provides for a real-time exchange of NAS aeronautical information used by strategic planners in the FAA as well as the airlines, DOD, and private industry.
- Strategic decision support tools use common data sets for data processing and distributing the results to all system users.
- NAS flight operations are monitored for real-time compliance, and system-level impact assessments are readily available to all system users.

15. Increased Ability To Support Search and Rescue Activities, NAS Management Services, NAS Information

Figure D-45 shows Phase 3 of this capability.

Phase 1 (1998–2002)

- No change in capability.

Phase 2 (2003–2007)

- No change in capability.

Phase 3 (2008–2015)

- Aircraft are equipped with satellite navigation and emit a 406 MHz signal that will be detected by one or more satellites, which then relay the aircraft positions to the National Oceanic and Atmospheric Administration (NOAA). The aircrafts' downed positions are then transmitted to the rescue coordination center.
- Normal emergency frequencies are monitored 24 hours a day and when they are detected, ATC facilities are notified. Once a true emergency has been confirmed, flight plan data and last-known position are forwarded to the rescue coordination center.

16. Improved Infrastructure Maintenance Management, NAS Management Services, Infrastructure Management

Figures D-46, -47, and -48 show Phases 1, 2, and 3, respectively, of this capability.

Phase 1 (1998–2002)

- NAS systems are continually monitored for acceptable performance. Reports of anomalies are transmitted to an operations control center (OCC).

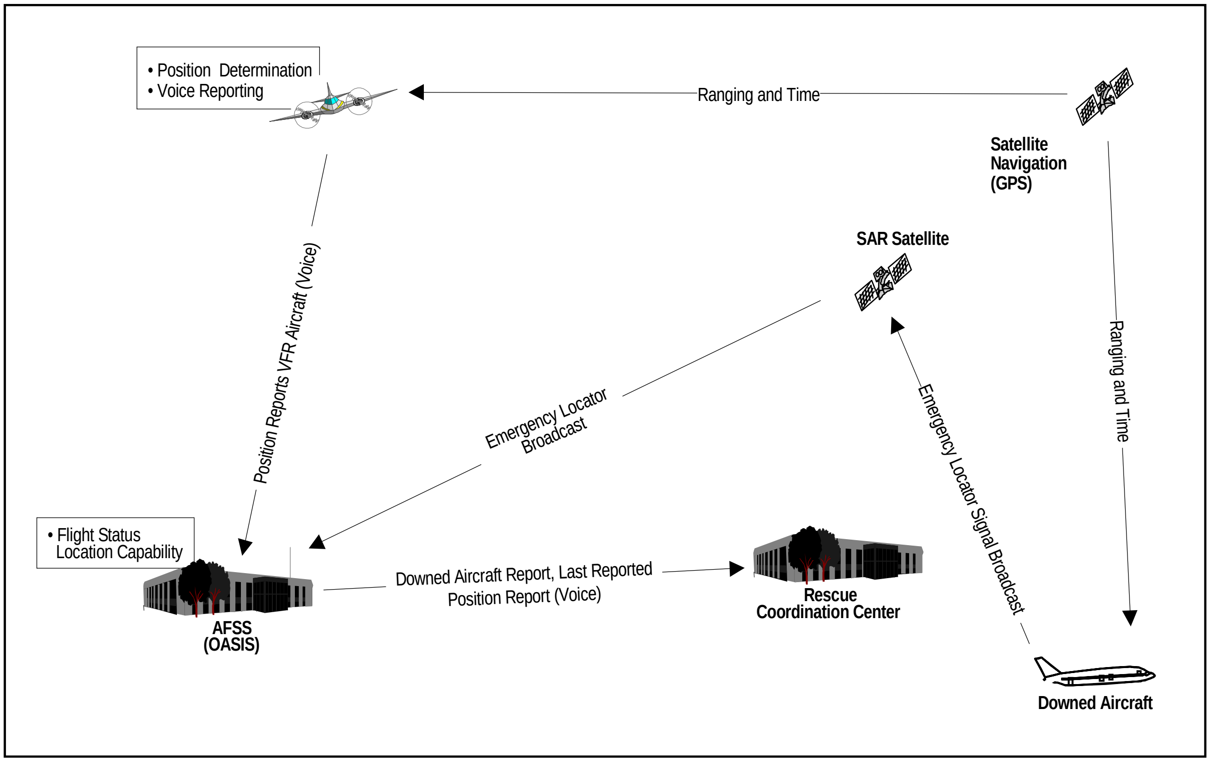

Figure D-45. Increased Ability To Support Search and Rescue Activities, NAS Management Services, NAS Information, Phase 3 (2008–2015)

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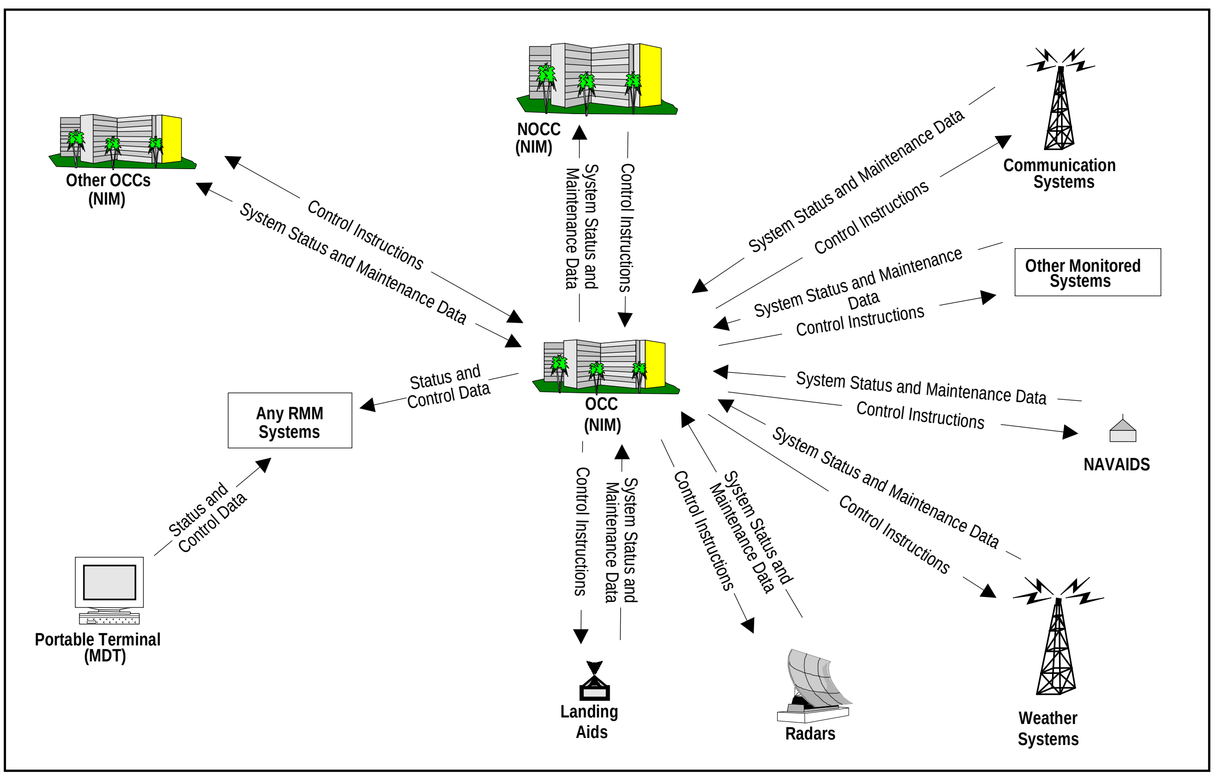

Figure D-46. Improved Infrastructure Maintenance Management, NAS Management Services, Infrastructure Management, Phase 1 (1998–2002)

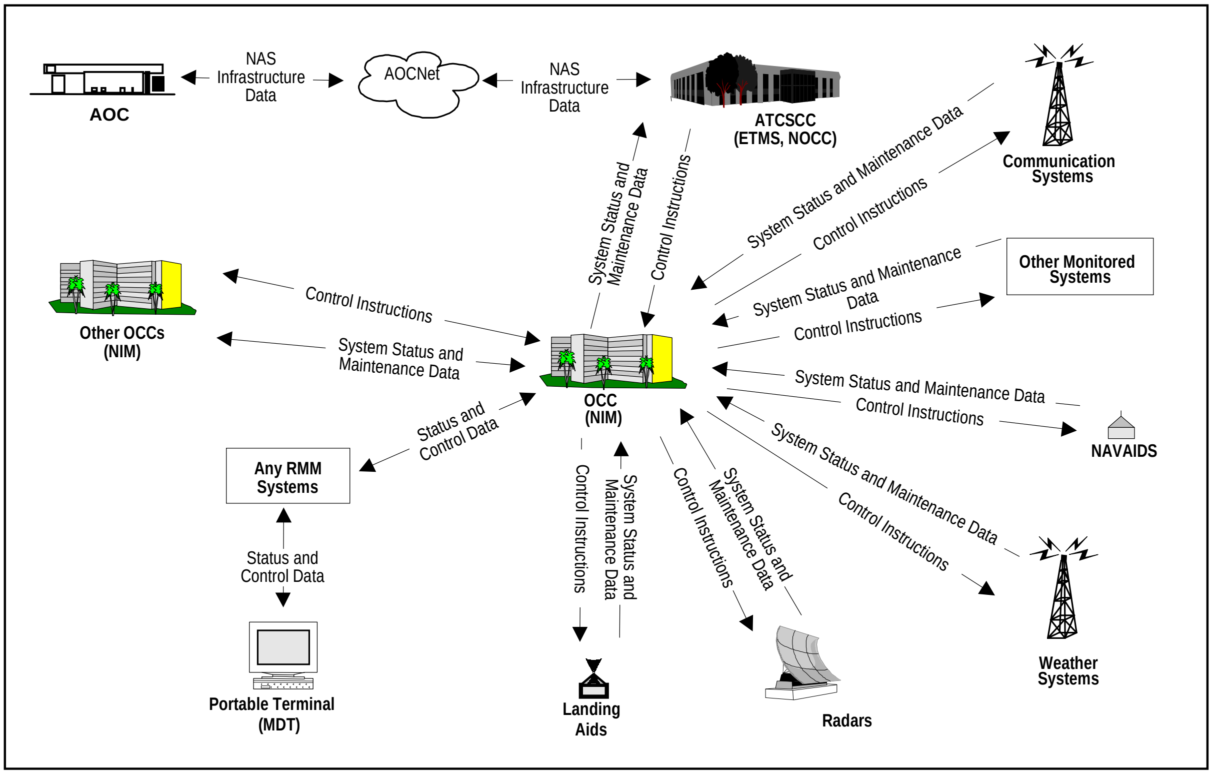

Figure D-47. Improved Infrastructure Maintenance Management, NAS Management Services, Infrastructure Management, Phase 2 (2003–2007)

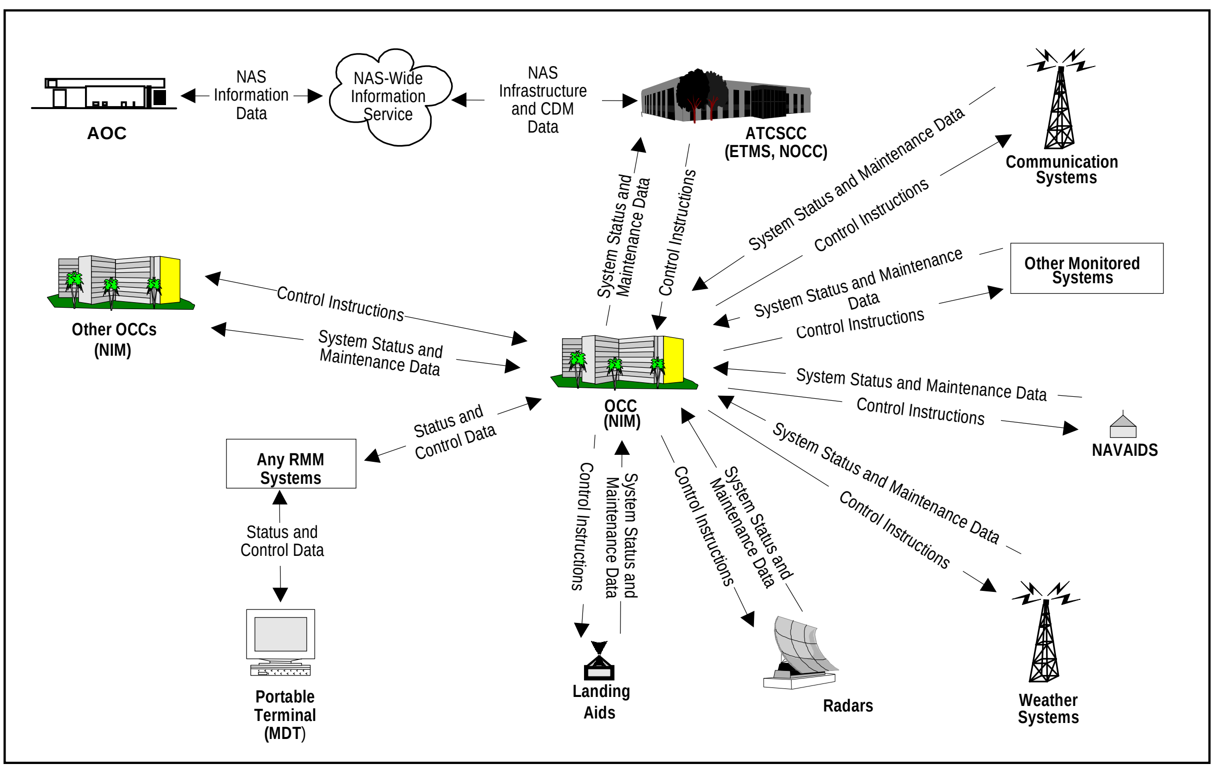

Figure D-48. Improved Infrastructure Maintenance Management, NAS Management Services, Infrastructure Management, Phase 3 (2008–2015)

PART V

- During and at completion of maintenance activity, the technician enters data into a maintenance data terminal (MDT) that forwards the information to the OCC for evaluation and storage.

- System status and selected performance parameters are periodically provided to the OCC. These parameters can also be read by the National Operations Control Center (NOCC) upon request.

- System status reports are sent from all OCCs to the NOCC for NAS impact evaluation and input to the traffic management operation.

- Selected systems accept configuration change instructions through the remote maintenance sensor (RMS) function (e.g., radar channel changes).

Phase 2 (2003–2007)

- As more NAS systems are monitored, the NAS facility status data become more accurate and available to users and service providers.

- CDM for maintenance activities allows for limited collaboration with users for scheduled maintenance activities.

Phase 3 (2008–2015)

- Improved CDM for maintenance activities allows for expanded collaboration with users for scheduling maintenance activities.

D.2 Capability Matrix

The capability matrix is divided into two parts. Part one addresses air traffic service capabilities throughout the active phase of flights. Part two addresses NAS management services that cross domains of flight or involve infrastructure management issues.

The matrix lists the 16 top-level capabilities identified in the NAS concept of operations (CONOPS). Each capability is addressed by phase of flight and phase of the modernization plan. The matrix columns contain functions needed to achieve the desired capability. The bold italic text is the commonly used name of the capability.

Table D-1. NAS Modernization Capabilities – Air Traffic Services

Capability	Tower/Airport Surface	Arrival/Departure	En Route/Cruise	Oceanic	NAS-Wide (Multiple Domains of Flight)
1. Increased Navigation/Landing Position Accuracy and Site Availability					
Phase 1.	No change in capability	***Initial WAAS Precision Approach Existing Airports*** Provides WAAS precision approaches to airports that currently have existing Category I or other approaches; actual approach minima will continue to be based on obstacle clearance, lighting, etc. ***Initial WAAS Precision Approach New Qualifying Airports*** Provides WAAS precision approaches to airports that currently do not have precision approaches; actual approach minima will continue to be based on obstacle clearance, lighting, etc.	No change in capability	***GPS Oceanic*** Provides pilots an additional, more precise and reliable means to determine aircraft position	***Terrain Avoidance*** Provides GPS-based vertical reference; provides pilots with enhanced ground proximity warning ***Initial WAAS Cruise*** Provides area navigation capability
Phase 2.	No change in capability	***LAAS CAT I*** Provides LAAS Category I precision approaches to airports not adequately covered by WAAS ***LAAS CAT II, III*** Provides LAAS Category II/III precision approaches to airports	No change in capability	No additional change in capability	No additional change in capability
Phase 3.	No change in capability	No additional change in capability	No change in capability	***Transition to En Route/Cruise***	No additional change in capability
2. Increased Exchange of Common Weather Data					
Phase 1.	Not applicable	***ITWS Stand-Alone*** Consolidates terminal weather information onto a single stand-alone display available to the controller for windshear and other hazardous weather information ***Initial TWIP*** Provides in-flight graphical terminal weather information to pilots based on TDWR data relayed through a service provider; this service is primarily for commercial carriers ***Expanded TWIP*** Provides in-flight graphical terminal weather information to pilots during flight based on data relayed through a service provider; this service is primarily for commercial carriers	***Weather on DSR*** Consolidates weather data onto the en route controller workstation, DSR; this enables selected LRR decommissioning ***Terminal Weather Exchange*** Provides a common weather data picture among the Traffic Management Specialist, terminal, and en route controllers	No change in capability	***MDCRS*** Enables the collection of real-time airborne weather data from participating aircraft and then integrates this collected data with other NAS weather products ***Enhanced MDCRS*** Provides collection of real-time airborne weather data, including temperature and humidity, from participating aircraft, and integrates the data with other weather products for NAS-wide distribution ***Initial FIS*** Provides NWS weather information to the pilot through a service provider; this service is primarily for general aviation

Table D-1. NAS Modernization Capabilities – Air Traffic Services

Capability	Tower/Airport Surface	Arrival/Departure	En Route/Cruise	Oceanic	NAS-Wide (Multiple Domains of Flight)
Phase 2.	Not applicable	***Improved Weather on STARS*** Consolidates terminal weather information onto a single integrated display available to the controller for windshear and other hazardous weather information	No additional change in capability	No change in capability	No additional change in capability
Phase 3.	Not applicable	***Automatic Simultaneous Hazardous Weather Notification*** Provides real-time windshear alert information to pilots	No additional change in capability	***Transition to En Route/Cruise***	No additional change in capability
3. Improved Aircraft Positional Accuracy Reporting to Service Providers					
Phase 1.	***ASDE with AMASS*** Alerts controllers to potential collision situations in the airport movement area at large airports; provides controllers with target identification to aid in the situational awareness ***ASDE*** Provides controllers with primary radar targets to aid in controlling surface traffic and for situational awareness	***Improved Terminal Surveillance (ASTERIX/SI)*** Improved aircraft position accuracy reporting to service providers	No change in capability	No change in capability	No change in capability
Phase 2.	***Runway Incursion Reduction*** Alerts controllers to potential collision situations in the airport movement areas for qualifying airports that do not have ASDE/AMASS; improves airport markings, signage, and lighting; improves the training for pilots about runway signage, lights, and markings	***Integrated Terminal Surveillance with ADS-B*** Provides controllers better position information about air traffic based on GPS; this is an intermediate step toward active FAST	***Improved En Route Surveillance (ASTERIX/SI)*** Improved aircraft position accuracy reporting to service providers ***Integrated En Route Surveillance with ADS-B*** Provides controllers better position information for air traffic based on GPS	No change in capability	No change in capability
Phase 3.	***Integrated Tower Area Surveillance*** Provides controllers better position information about the air traffic based on GPS; also provides controllers integrated information about the arriving aircraft and airport surface aircraft	No additional change in capability	No additional change in capability	***Transition to En Route/Cruise***	No change in capability

Table D-1. NAS Modernization Capabilities – Air Traffic Services

Capability	Tower/Airport Surface	Arrival/Departure	En Route/Cruise	Oceanic	NAS-Wide (Multiple Domains of Flight)
4. Increased Self-Separation by Properly Equipped Aircraft					
Phase 1.	Not applicable	No change in capability	No change in capability	No change in capability	***Air-Air ADS-B*** Provides pilots a cockpit display of traffic information of other properly equipped ADS-B aircraft ***TIS via Mode-S*** Provides air traffic surveillance information to properly equipped in-flight aircraft using Mode-S
Phase 2.	Not applicable	No change in capability	No change in capability	No change in capability	No additional change in capability
Phase 3.	Not applicable	No change in capability	No change in capability	***Transition to En Route/Cruise***	No additional change in capability
5. Increased Surveillance Area Coverage					
Phase 1.	Not applicable	No change in capability	No change in capability	No change in capability	No change in capability
Phase 2.	Not applicable	No change in capability	***Enhanced En Route Radar Coverage*** Provides en route controllers with terminal radar data, thereby covering some areas where ARTCC radar service does not presently exist ***ADS-B Gap-Filler*** Provides controllers with expanded ability to offer separation services in remote areas that are currently not covered by radar, by providing the controllers the ability to receive aircraft position broadcasts	***Oceanic Surveillance via ADS-A*** Provides controllers more timely and more accurate position information about oceanic aircraft	No change in capability
Phase 3.	Not applicable	No change in capability	No additional change in capability	***Transition to En Route/Cruise***	No change in capability
6. Increased Digital Voice and Data Communications Among Service Providers and Pilots					
Phase 1.	***TDLS*** Provides predeparture clearance and ATIS via service provider data link at a limited set of airports.	No change in capability.	***CPDLC Build 1*** Provides lead-in test period that allows controllers and pilots to directly exchange a limited set of data link non-time-critical messages in the en route environment ***CPDLC Build 1A*** Provides for national deployment of a limited set (18) of non-time-critical data link messages	***Oceanic Data Link*** Provides controllers and pilots in an initial single sector environment to exchange digital data messages for control purposes in oceanic airspace ***Multisector Oceanic Data Link*** Provides controllers and pilots the ability to exchange digital data messages throughout the oceanic airspace	No change in capability.

Table D-1. NAS Modernization Capabilities – Air Traffic Services

Capability	Tower/Airport Surface	Arrival/Departure	En Route/Cruise	Oceanic	NAS-Wide (Multiple Domains of Flight)
Phase 2.	**Expanded *TDLS*** Provides pilots with predeparture clearance and ATIS via service provider data link at an expanded number of airports; allows specific set of data transmission from tower controller to aircraft	No change in capability	***CPDLC Build 2 via VDL-Mode-2*** Allows ATC and pilots to directly exchange digital messages in non-time-critical situations in the en route environment	No additional change in capability	No change in capability
Phase 3.	No additional change in capability	No change in capability	***CPDLC Build 2 via VDL-Mode-3*** Increased digital voice and data communications between service providers and pilot	***Transition to En Route/Cruise***	***CPDLC Build 3 via VDL-Mode-3*** Increased digital voice and data communications between service providers and pilot ***NAS-Wide Data Link*** Allows controllers and pilots to directly exchange digital messages, such as FIS and TIS information throughout the NAS
7. Improved Flight Plan Negotiation					
Phase 1.	No change in capability	No change in capability	No change in capability	No change in capability	No change in capability
Phase 2.	No change in capability	No change in capability	No change in capability	No change in capability	No change in capability
Phase 3.	No change in capability	No change in capability	No change in capability	***Transition to En Route/Cruise***	***Interactive Airborne Refile*** Provides in-flight, electronic exchange and automated processing of flight plan change requests between pilots and controllers for entire route clearance
8. Improved Arrival and Departure Sequencing and Spacing for Tactical Traffic Flow					
Phase 1.	Not applicable	***pFAST (FFP1)*** Provides terminal controllers new tools to allow better sequencing and runway assignment of aircraft on final approach to congested airports	***Single Center Metering (FFP1)*** Provides the en route controllers and traffic managers with arrival scheduling tools to optimize traffic flow from a single center to a high-activity airport within that center's airspace	Not applicable	No change in capability
Phase 2.	Not applicable	No additional change in capability	***Multicenter Metering with Descent Advisor*** Provides the en route controllers and traffic managers with arrival scheduling tools to optimize traffic flow from multiple centers to a high activity airport near a center's boundary	Not applicable	No change in capability

Table D-1. NAS Modernization Capabilities – Air Traffic Services

Capability	Tower/Airport Surface	Arrival/Departure	En Route/Cruise	Oceanic	NAS-Wide (Multiple Domains of Flight)
Phase 3.	Not applicable	***aFAST with Wake Vortex*** Provides new tools to the controller to allow better sequencing, spacing, and runway assignment of aircraft on final approach to congested airports; includes refined considerations for wake vortex and specific aircraft characteristic algorithms	No additional change in capability	Not applicable	No change in capability
9. Increased Flexibility in Flying User-Preferred Routes					
Phase 1.	Not applicable	Not applicable	***URET CCLD (FFP1)*** Allows D-side controllers to better manage en route traffic with an increased awareness of potential conflict situations; additionally, allows controllers to grant user requests through the use of a trial planning capability; the capability is limited to selected centers and sectors within those centers	No change in capability	No change in capability
Phase 2.	Not applicable	Not applicable	***Conflict Probe*** Allows D-side controllers to better manage en route traffic with an awareness of potential conflict situations; additionally, allows controllers to grant user requests through the use of a trial planning capability; this capability allows additional sites beyond URET CCLD	No additional change in capability	No change in capability
Phase 3.	Not applicable	Not applicable	***Conflict Resolution with Multicenter Metering*** Provides controllers flight plan recommendations as consideration for providing optimum separation services to solve potential conflicts	***Transition to En Route/Cruise***	No change in capability
10. Increased Airspace Capacity					
Phase 1.	Not applicable	Not applicable	No change in capability	***RVSM/50 Lateral*** Enables the controller and the pilot to negotiate passing maneuvers within the oceanic domain	Not applicable
Phase 2.	Not applicable	Not applicable	No change in capability	***50/50*** Provides tools to the controller to enable reduced separation standards to be utilized for properly equipped aircraft	Not applicable
Phase 3.	Not applicable	Not applicable	No change in capability	***Transition to En Route/Cruise***	Not applicable

Table D-1. NAS Modernization Capabilities – Air Traffic Services

Capability	Tower/Airport Surface	Arrival/Departure	En Route/Cruise	Oceanic	NAS-Wide (Multiple Domains of Flight)
11. Improved Surface Traffic Management					
Phase 1.	***Atlanta SMA*** A prototype decision aid for controllers that provides recommended taxi routes for arriving and departing aircraft to optimize surface movement ***Initial SMA (FFP1)*** Provides airport ramp and control operators with a one-way feed of current traffic information not previously available; this availability is at selected airports for participating airlines	Not applicable	Not applicable	Not applicable	Not applicable
Phase 2.	***SMA*** Provides additional tools that provide controllers with recommended taxi routes for arriving and departing aircraft for optimizing surface movement ***SMS*** Provides airport configuration, aircraft arrival/departure status, and airfield ground movement advisories to controllers, dispatchers, and traffic flow managers; it will interface with AMASS and the terminal automation to help controllers coordinate arrival/departure flows with surface movements	Not applicable	Not applicable	Not applicable	Not applicable
Phase 3.	***Enhanced SMS*** Provides additional tools for the exchange of terminal and airport surface data between ATC and AOCs in a manner that supports the efficient movement of aircraft on the airport surface; it will enable users and providers to have access to flight planning, traffic management, arrival/departure, and weather information	Not applicable	Not applicable	Not applicable	Not applicable
12. Increased Low-Altitude Direct Routes					
Phase 1.	Not applicable	Not applicable	No change in capability	Not applicable	***Low-Altitude Direct Routes Using WAAS*** Provides low-altitude direct routes to be flown by WAAS-equipped aircraft

Table D-1. NAS Modernization Capabilities – Air Traffic Services

Capability	Tower/Airport Surface	Arrival/Departure	En Route/Cruise	Oceanic	NAS-Wide (Multiple Domains of Flight)
Phase 2.	Not applicable	Not applicable	No change in capability	Not applicable	***Low-Altitude Direct Routes, Expanded Radar Coverage*** Provides additional low-altitude direct routes in areas that are currently served by radar by integrating revised airspace design and air-ground communications ***Low-Altitude Direct Routes, Expanded Surveillance Coverage*** Provides integrated and expanded surveillance coverage for additional low-altitude direct routes for properly equipped aircraft in nonradar areas
Phase 3.	Not applicable	Not applicable	No change in capability	Not applicable	No additional change in capability
13. Increased Availability of Aeronautical Information to Service Providers and NAS Users					
Phase 1.	No change in capability	No change in capability	No change in capability	No change in capability	No change in capability
Phase 2.	No change in capability	No change in capability	No change in capability	No change in capability	No change in capability
Phase 3.	***Transition to NAS-Wide***	***Transition to NAS-Wide***	***Transition to NAS-Wide***	***Transition to NAS-Wide***	***NAS-Wide Information Sharing*** Provides for the timely and accurate dissemination of NAS information among the aviation community, including international sharing of appropriate flight planning information

Table D-2. NAS Modernization Capabilities – NAS Management Services

Capability	Traffic Management	NAS Information	Infrastructure Management
14. Improved CDM Between Service Providers and NAS Users for Strategic Planning			
Phase 1.	***AOCNET*** An existing information exchange among participating AOCs and the FAA to facilitate traffic management ***Initial CDM*** Provides participating AOCs and the FAA with real-time access to current NAS status information, including infrastructure and operational factors	Not applicable	Not applicable
Phase 2.	***Flight Plan Evaluation*** Provides interactive feedback to NAS users proposed flight plans based on current constraints such as special use airspace and equipment status	Not applicable	Not applicable
Phase 3.	***Full CDM*** Provides more robust interactive feedback to NAS users proposed flight plans based on current constraints such as special use airspace, equipment and facility status, and weather conditions	Not applicable	Not applicable
15. Increased Ability To Support Search and Rescue Activities			
Phase 1.	Not Applicable	No change in capability	Not applicable
Phase 2.	Not Applicable	No change in capability	Not applicable
Phase 3.	Not Applicable	***ELT for SAR and Flight Following*** Provides GPS location information and discrete aircraft identification of downed aircraft through satellite-based communications	Not applicable
16. Improved Infrastructure Maintenance Management			
Phase 1.	Not Applicable	Not Applicable	***Increased RMM*** Provides improved and more consolidated remote monitoring for NAS facilities
Phase 2.	Not Applicable	Not Applicable	***CDM for Maintenance Activity*** Allows for limited collaboration with users for scheduled maintenance activities
Phase 3.	Not Applicable	Not Applicable	***Improved CDM for Maintenance Activities*** Allows for expanded collaboration with users for scheduling maintenance activities